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THE RIVER PILCOMAYO

from its discharge into the River Paraguay
to Parallel 22° S.

WITH

MAP OF REFERENCE
DETAILED MAP IN SEVEN SHEETS
SKETCH OF ROUTES

BY

GUNNAR LANGE

M. A. M. SOC. C. E.

TRANSLATED FROM THE ARGENTINE ORIGINAL



BUENOS AIRES

Printed in the Press of the Argentine Meteorological Office

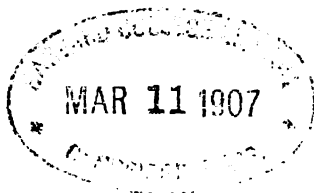
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M.

Sir
I have the honour to beg that you will accept a copy of

THE RIVER PILCOMAYO
from its discharge into the River Paraguay
to Parallel 22° S.
WITH
map of reference, detailed map in seven sheets, sketch of routes.

I am Sir your obedient servant.

J. Lange

Buenos Aires, December 1906.

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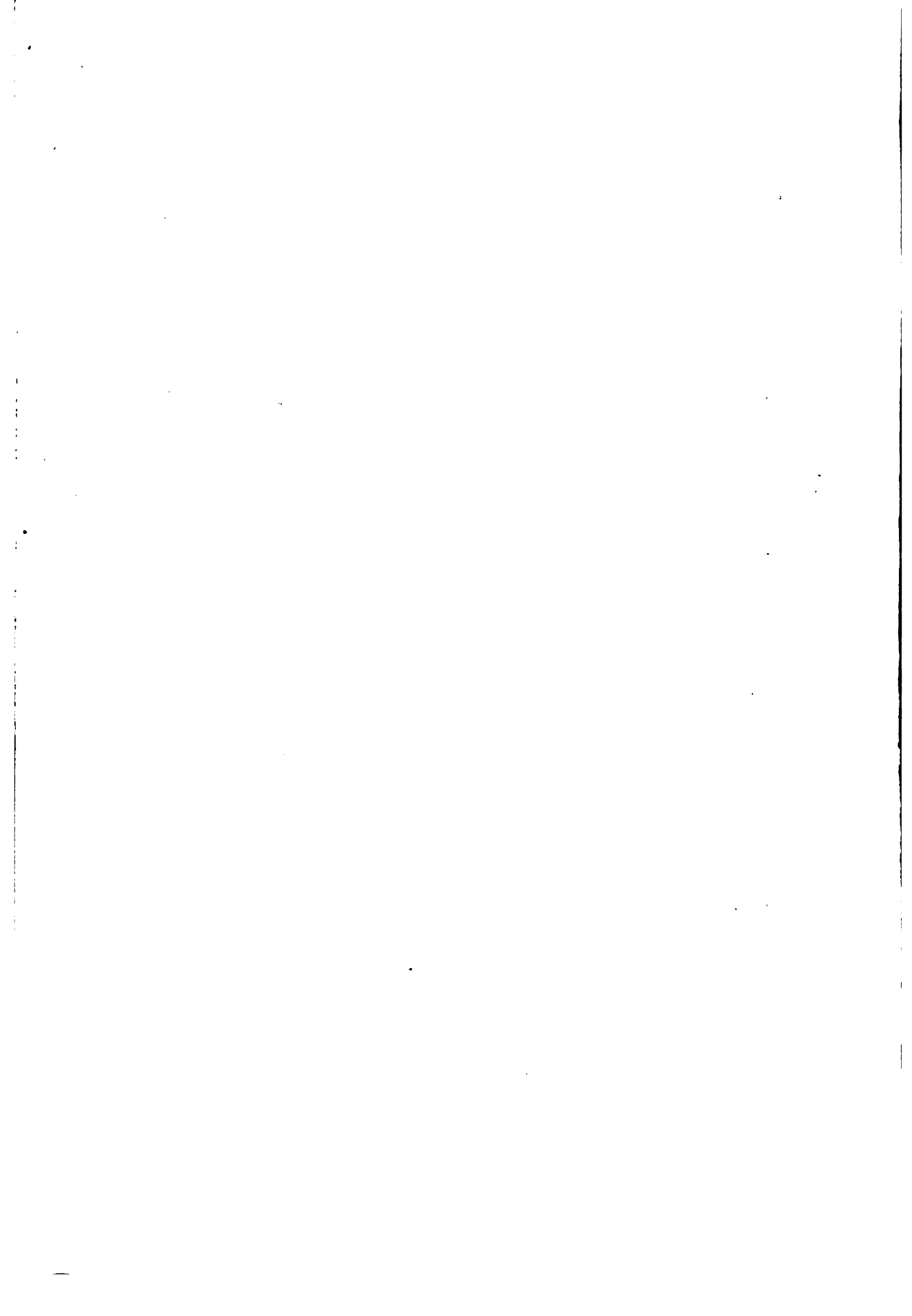
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INTRODUCTION

The river Pilcomayo has its source in the Bolivian mountain ranges and as a broad and ample stream it traverses the virgin forests of the Gran Chaco, in a general direction from N. W. to S. E.

According to the scanty data available respecting its course through that wooded region, it was presumable that to the south of parallel 24", it ceases to be a united stream in a defined channel and that it scatters its waters over lagoons and extensive marshes. Towards the S. E. at the limits of the marshes, these waters collect and form brooks and rivers which, united in several branches, already studied by different explorers, discharge into the river Paraguay. One of these branches which discharges opposite the Cerro Lambaré, down stream from Asuncion, has been considered as probably the most direct continuation of the upper Pilcomayo and shown on the maps under that name, although it was not yet known in what manner the communication between the upper and lower portions was effected.

Since nearly two hundred years ago the idea of utilizing the river Pilcomayo for purposes of navigation has engaged the attention of the governments of Argentina, Bolivia and Paraguay, also of private explorers; and several expeditions have attempted to ascend or descend the river along its proper course.

It is superfluous to prove the importance of providing the rich regions of the Chaco Central with an easy means of communication and to afford the natural products of the fertile zones of the south eastern part of Bolivia with an outlet by water to the navigable inland rivers.

A syndicate of capitalists composed of Messrs. Federico Portalis, Mauricio Mayer, Enrique Berduc, Marcelo Dumais, Cecilio Lopez, Juan Bautista Mignaqui, Pedro Mihanovich, Victor Negri, Ricardo Petersen and Miguel Piñero Sorondo, decided, about the end of June 1905, to send an expedition to study the navigable conditions of the river Pilcomayo from its discharge into the river Paraguay up to the colony Buena Ventura, near parallel 22", and were pleased to offer the command of the same to the author of this report.

I accepted this flattering offer with pleasure, and as Chief of the Hydrometric Section of the Argentine Meteorological Office, I petitioned the Ministry of Agriculture for the requisite authorization, which in view of the general interest afforded by the object of the expedition was granted on condition that the studies and plans, etc. be communicated to the Ministry referred to.

It was already late in the year to begin preparing for a journey to the Chaco, which should last at least about 5 months, so that there was no time to lose.

I looked up and studied all the data and reports obtainable on former journeys to the river Pilcomayo, and extracted the lessons, noted further on, which were decisive for our undertaking.

The river Pilcomayo has its first sources in Bolivia, in the mountain chain Los Frailes, in the Oruro Department, to the westward of the city of Sucre; it runs first eastward and then, in a general direction SE, cutting its channel across the Bolivian mountain ranges, emerging onto the plains of the northern Chaco by a narrow gorge cut through the Caiza range above the town of San Francisco; receives several important affluents from the neighbouring hills, among these being the river Cuchimayo which waters the gardens of the above mentioned city, and the river Pelaya whose affluents rise, in the Potosi department, in the San Vicente mountains. When it emerges from its rocky channel onto the open country, the river Pilcomayo carries a very considerable volume of water which in very high freshets amounts to at least 2000 cubic metres per second. This great mass gradually diminishes as it passes over loose and sandy soil from parallel 21°-30' towards the south, where it meanders in a very unstable channel and passes the Argentine colony Buena Ventura.

In the south of parallel 24° the river loses itself in great marshes and lagoons which constitute the zone known as the Estero Patiño, and only after passing 24°-30' S latitude does it resume a definite course, to continue with well defined banks until it falls into the river Paraguay, about 5 kilometers from Asuncion and as stated before, in front of the picturesque Lambaré hill.

The river Pilcomayo is in all 1700 kilometers (340 leagues) long, and is fed throughout a region of approximately 126.400 square kilometers (5056 square leagues) in extent.

It may be of interest to present here in chronological order a list of the exploring expeditions hitherto undertaken in the river Pilcomayo.

Year 1721. Father Patiño left Asuncion in a very large boat and ascended the river for, it is stated, a distance of 471 leagues.

1741. Father Castañeda and later on, Father Casales.

1785. Father Azara.

1843. Colonel Margarinos, Bolivian

1844. Naval Sub lieutenant, von Nievel | From Bolivia

1882. J. Nicolas Crevaux. French Doctor |

1884. Commander J. L. Fontana and Major
Valentin Feilberg, of the Argentine
Navy

| From the river
| Paraguay

1890. Engineer Olaf Storm

1890. Captain Juan Pages, of the Argentine
Navy.

1898 to 1901. Engineers G. and A. Sol made a detailed map from the mouth of the river as far as 198 kilometers.

1898. Engineer Ibarreta, from San Antonio in Bolivia to the Estero Patiño.

Particulars more or less complete respecting all these journeys and studies may be found in the library of the Argentine Geographical Institute, which in its important journal has published a number of interesting reports and articles referring to the river Pilcomayo and its explorations.

CHAPTER I

PROGRAMME OF THE JOURNEY AND PREPARATIONS — METHODS AND OPERATIONS OF THE STUDY.

On the 20th July it was finally decided to carry out the expedition, and the following day I handed to the syndicate afore mentioned the following proposal for the organization of the members and equipment and also the programme of the journey and studies.

PILCOMAYO

STUDY OF ITS NAVIGABILITY FROM THE RIVER PARAGUAY AS FAR AS THE COLONY BUENA VENTURA

Many explorers have crossed the Paraguayan and Argentine Chaco mounted and even on foot to the north and to the south of the river Pilcomayo, but none have yet succeeded in crossing that region going in boats up or down the course of the river.

Several times this has been attempted, both from Bolivia and from the river Paraguay, but invariably such efforts have been foiled by the great swamps of the Estero Patiño, which extends to the south of parallel 24°.

Studying the accounts of the different attempts at navigation, it became apparent that failure was due to the two following circumstances:

1. The use of boats of too much draft and especially of too great weight.
2. Insufficiency of provisions.

In order to undertake the study of the river Pilcomayo with any hope of success, it will be necessary to make arrangements to secure an ample supply of provisions, at the time and in the locality of most work, and that the boats used be of such reduced size and weight as to be easily carried over obstacles.

This opinion of the undersigned has been confirmed after a

conference with the Chief of Police of Formosa, Don Ulpiano Cáceres, who is well acquainted with those parts, and we have decided to recommend the organization of the party, equipment, plan of the journey and studies as follows:

EXPLORING PARTY

1^{stly} Water division:

1	Chief of studies	1	Storekeeper
1	Second Chief	2	Foremen
1	Assistant	2	Interpreters
		18	Men
<u>3</u>	<u>Chiefs</u>	<u>23</u>	<u>Subalternes</u>

2^{ndly} Land Division:

1 foreman, 1 carter, 6 men, in all 8 persons, besides the land and forest experts.

TRANSPORT ANIMALS

18 saddle animals, 12 oxen and besides the mounts for the experts.

CATTLE FOR CONSUMPTION.

30 bullocks for the river division and 10 for the land division.

BOATS

1	boat.....	9	ms. by	1.50,	load	2.500	kilos
3	"	5	" "	1.50	"	1.500	"
1	"	5	" "	1.—			

Instruments, tools and provisions as per list.

PROGRAMME OF ROUTE AND STUDIES.

1^{stly} To send the land division with animals and provisions up to the Estero Patiño.

2^{ndly} To ascend the river with a hired steam tug up to the Estero Patiño, with provisions for 2 1/2 months (including jerked beef for 20 days) without delaying for a close study of the lower course of the river.

3^{rdly} To send back the tug and the largest boat to return with the remainder of the provisions for 5 months.

4^{thly} To cross and study the Estero Patiño.

5^{thly} Penetrate as far as Buena Ventura, following the course of the river, and study the works necessary to make it navigable.

6^{thly} To send exploring parties to the north and south of the river to examine the land.

7^{thly} To return down river and make a close study of the lower course of the river, from the Estero Patiño to the mouth.

Buenos Aires, 21 July 1905.

Signed: G. LANGE.

Agreed to

Signed: F. PORTALIS — MAURICIO MAYER.

For the different posts detailed in the foregoing list the following were named:

Chief of studies.....	Engineer Gunnar Lange
Second Chief.....	Ulpiano Cáceres
Technical Assistant	Oscar M. Mayer
Land and forest expert.....	José Casanova
Storekeeper.....	Arturo Cáceres
1 st foreman.....	Miguel Mas de Ayala

In the two divisions there was a total of 26 persons, besides 4 auxiliaries, guides and interpreters.

The total number of animals taken was:

22 mules, 41 horses, 16 oxen and 22 bullocks for food.

The boats taken were:

1 boat large.....	11 ms. long drawing 0.60 ms. loaded
2 "	8 " " " 0.30 " "
1 "	7 " " " 0.35 " "
1 "	5 " " "

The programme above mentioned having been accepted, preparations were at once set on foot to procure, arrange and pack the necessary equipment and provisions, a task which was facilitated by the practical and decided assistance of Mr. Mauricio Mayer, member of the Syndicate and as regards the steam tug and the boats, by the cooperation of the firm of Mihanovich.

By the end of July all was ready and on the 1st of August Mr. Cáceres left for Formosa to collect men and animals. On the 3rd of the same month I set out in company with Mr. Oscar Mayer. On the 9th we arrived at Asuncion. Here and in Clorinda, near the mouth of the Pilcomayo the final arrangements were carried out

with the efficacious help of the manager of the firm of Mihanovich in Assumption, Mr. Florentino Gorleri.

On the 15th of August the first permanent hydrometric gauge was fixed in the river Pilcomayo, the custody and observation of it being confided to Mr. Severo Pujato Crespo, Commissary of police in Clorinda.

On the 17th and 18th I took observations of latitude and azimuth to determine the variation of the compass and on the 19th of August we had the pleasure to communicate to the President of the "Syndicate Pilcomayo", Mr. Federico Portalis, that both the land and the river divisions had started on the journey towards the NW.

Mr. Cosanova was instructed to try to reach the "Tapera Bailón" by the 5th of September at latest.

I have used with much profit for my hydrographic notes of the lower part of the river the map constructed by the engineers G. and A. Sol, in 1:10,000 scale, starting from the mouth of the river and ending at the old Franciscan mission, on the southern bank of the lower Pilcomayo; 298 kilometers by river and 116 in a straight line.

When we began our study, the river Paraguay and the lower Pilcomayo were much swollen, so that as regards soundings in low water, I may refer to those marked on said map as they were taken at a time of medium depth of water.

The river Pilcomayo discharges into the river Paraguay opposite the island Yuqueti, below the branch which separates the said island from that of Tacumbó.

At the mouth of the Yuqueti the mean depth of low water is 3 metres, and from there up to Colonia Clorinda, the old Fotheringham fort, the transverse sections of Sol's map show no soundings of less than 6 metres.

In general, as already stated, so far as regards the topographical and hydrometric data, I can refer to the excellent map of the engineers Sol, which I have verified on the spot during the navigation of the river, as far as the end of their survey of the southern branch.

I must however observe that as regards the geographical latitude of the principal points we are not wholly agreed, whilst my astronomical observations are nearly identical with those made by Olaf Storm, engineer and naval officer.

Making use of Sol's map graphically by placing its polygon over the polyconical projection constructed for the preparation of my map and making it turn on a common starting point—the sub prefecture at the mouth—so far that the extreme point of Sol's map coincides with my observation of latitude, there results a longitude somewhat more to the west.

It is worthy of mention, that the angle of this rotary movement is approximately 4°, which is very nearly the same as the variation of the compass to the east, observed by me in the Colonia Clorinda.

	Latitude	Longitude	Observer
Junta Fontana.....	24°—53'—47"	0°— 6'— 3" E of Bs. As.	Sol
	24 —56—19	0 — 6 —27	Storm
	24 —56—14	0 — 3 —52	Lange
Final point map Sol	24 —42—28	0 —21—29 W of Bs. As.	Sol
	24 —46—20	0 —24—55	Lange
Junta Dorado	24 —28—0	1 — 1 — 0	Storm
	24 —27—51	1 — 1 — 0	Lange

The longitude of Bs. Aires is 58° - 22' - 15" west of Greenwich.

The plan of the course of the river and of our route in the Estero Patiño up river from the point where Sol's map ends has been based on distances observed telemetrically with engineer Emilio Palacio's telemetre, with its corresponding distance rod, these distances being referred to the magnetic north with a good boat's compass, the variation in the declination of the magnetic needle being duly taken into account. This telemetric survey was continued without interruption in the boat and on foot and on horseback in distances relatively short, where communication by water was impossible, as far as parallel 22°, supported and controlled by 15 astronomical observations of geographical latitude.

There were in all 792 kilometers of continuous telemetry, with a satisfactory result as to precision inasmuch as in the construction of the map marking the final point, the boundary N° 1 of parallel 22°, there was found to be naturally no appreciable error in the direction north and south, and in the direction west and east a difference of 1250 metres.

This difference in longitude is not great in proportion to the length of the polygon and considering the method of survey applied, taking into account also the probable error in the determination of the geographical longitude of the starting point, extreme west of Sol's map and the final point, boundary N° 1 of parallel 22°. This affords a proof of the soundness and practical utility of the telemetric method for topographical surveys in long journeys, especially as very little time is required for making and noting the necessary observations. The result has been a triumph for the inventor of the instrument, and for the writer a recompense for his sufferings from the heat and eye troubles under the midday sun in those tropical regions.

As we advanced in our navigation, by at once applying the data observed, I constructed the map of the river in the scale 1:20.000.

The 54 sheets of this original map have been reduced to a map of 7 sheets in the scale 1:100.000, the smallest that could be adopted without losing the details of the many and very pronounced bends in the river, and at the same time give an idea of the topographical labour accomplished.

I may call attention to a geographical peculiarity of the general direction of the course of this long river which deviates so little from a straight line that its course can be shown, in the scale selected, from the intersection of parallel 22° down to its mouth, on a map six metres and a half long by half a metre wide.

As regards the topographical drawing on the map presented, I consider it proper to remark, that no details have been set down, which have not been actually observed. This gives the map in certain portions rather a bare aspect, due to the fact that in the wooded plains of the Great Chaco there is an absence of elevated points of observation, and its hydrographic system is so irregular that one cannot and should not mark any details based on stories and reports of guides and indians.

During the exploration I determined the volume of water flow per second at 12 different principal points, and the velocity of the current at a great many points throughout our passage up the river. Also I made such observations of level as our limited time permitted and which were necessary for this preliminary study, and endeavoured by means of barometric readings to give an idea of the elevations throughout our route.

Twenty seven barometric readings in the camp at Baradero in the southern branch, compared independently with simultaneous observations at Asuncion and in the Franciscan monastery near Formosa, gave an altitude of 94 metres over the zero of the Riachuelo in Buenos Aires, which does not agree with 107 metres, calculated by the engineers Sol for the Junta Fontana.

Nevertheless I retain 94 metres for Baradero, as this gives a longitudinal section of the river more logically probable and natural, with an incline diminishing from the Junta Dorado to the mouth of the Pilcomayo.

At the following points, Clorinda, Puerto Galileo, Buena Ventura and Fort Guachalla, hydrometric gauges were placed and arrangements made for their preservation and observation for account of the Hydrometrical Section, in order to secure data of the daily fluctuations of the river, which patiently and continuously accumulated

during a sufficiently long time will form the basis for the hydraulic works.

As regards meteorological observations, these were limited to noting barometric pressure and temperature for the calculation of the altitude for the principal points and the temperature every morning, when breaking up camp.

These observations which refer almost every day to a different spot, give a very incomplete idea of the atmospheric conditions, and for this reason I have not reproduced them in this narrative. More exact information on the subject may be found in the observations taken by the Franciscan fathers in the Tacaglé mission to the south of the river Pilcomayo, up stream from the Junta Fontana, where there is a station of the Argentine Meteorological Office.

The climate is sub-tropical, moist in the regions nearest to the river Paraguay, becoming gradually drier towards the west. We did not perceive the existence of climatic fevers or other sicknesses due to natural conditions.

CHAPTER II

NARRATIVE OF THE JOURNEY AND PROGRESSIVE DESCRIPTION OF THE RIVER

August 19th, 2 p. m.—We started from Clorinda in the five boats towed by the steam launch "Progreso", the length of the tow being 58 metres, and after going 26 kms. we passed the mouth of the Porteño brook.

3.45 p. m. *Obraje Gil* or as more poetically called, *La Barranquera de la Novia* (The Bride's Bluff). Distance from the mouth of the river 31.7 kms.; in straight line 15 kms. Distance travelled 12 kms.

A little above Clorinda we came across the *Reventon* (big break) through which in times of high freshets the river Pilcomayo flows over into the little Rio Negro which carries fresh water.

At the Obraje Gil there rises a fine bluff which was not covered by the last freshet. On the opposite side of the river the cultivated fields were covered by the water.

We noticed some totora plants (*Typha dominguensis*), our future enemy, a reed like cane with bulky tangled roots.

Aug. 20th, Obraje Gil.—River with tendency to fall.

Velocity of the stream 20 centimetres per second, or less than half a mile an hour.

9.10 a. m. Departure. Beyond the very tortuous turns in km. 43 the shores generally begin to rise.

The vegetation on the banks begins to change and indicates a drier soil.

There are traces of a freshet 4 metres over the present height of the river.

Many chacarés (alligators) pay dearly for their sluggishness in taking refuge under water from our rifles.

6.30 p. m. Camp, 76.6 kms. from the mouth of the river; in straight line 33.90 kms. Distance travelled 44.9 kms.

Aug. 21st. kms. 77—High abrupt banks—Suitable for a port.

The small supply of coal for the steamer having been exhausted it became necessary to hew wood.

10.40 a. m. Departure. I began to take soundings in the shallower transverse sections shewn on Sol's map and now note below the depth measured, with the corresponding depth of Sol's section in parenthesis.

SOUNDINGS.

Section Sol N° 27, Max. depth 8 ms. (Sol 2.05), kms. from mouth 77.6
" " 29, " 7.8 " (" 2.86), " " 83.4

The river runs in a cañon like bed, much like some rivers in the province of Cordoba.

On both sides, more especially from the north there are many brooks that drain the fields into the river.

The transverse section of the river has the typical form of alluvial rivers, with banks higher than the adjacent lands.

1.15 p. m. *Puerto Galileo.* From the mouth 88.2 kms., in straight line 58.55. Distance transversed to-day 11.6 kms. Depth in front of the port 6.75 ms.

According to Mr. Cancio, administrator of the factory, the river might fall 6.45 metres lower and rise 3 metres over its present level, which would represent a fluctuation in this port, between 0.30 and 9.75 metres.

Near port Galileo, on the Paraguayan coast there are four important "obrajes" (wood cutting stations) and two grazing farms, with fine woods and pasturage, belonging to Messrs. Testoni, Semino, Gorleri and Cancio, where preparations are being made for the erection of a tannin factory. According to Mr. Gorleri, the river is navigable during the greater part of the year as far as the port, for river boats of 400 tons.

I fixed a hydrometric gauge and placed it in charge of Mr. Eugenio Fogues.

Aug. 22. Puerto Galileo.—The river fell 6 cms. in 13 hours.

SOUNDINGS.

Section Sol N° 30, Max. depth 9.30 ms. (Sol 6.2), kms. from mouth 89.5
" " 34, " 5.74 " (" 1.85), " " 100.0

10.30 a. m. Riacho Paraguay and Obraje Cancio.

At the Obraje Cancio we met the Franciscan Father Guido De Petri of the Tacaglé mission, who was trying with a steam

launch furnished by the national government to find some navigable brook by which to communicate with the present site of the mission.

SOUNDINGS.

Section Sol N° 35, Max depth 6.70 ms. (Sol 2.08), kms. from mouth 103									
»	»	»	57,	»	6.30	»	(» 2.46),	»	»
»	»	»	39,	»	5.20	»	(» 0.52),	»	»
»	»	»	44,	»	4.50	»	(» 1.53),	»	»
»	»	»	45,	»	3.80	»	(» 1.23),	»	»
									110
									112
									127
									129

We passed dry and more open lands. Occasionally the banks are without woods.

So far little variation noticeable as regards wild birds.

5.05 p. m. Camp on bluff 6 ms. over present level of water. Laurel trees abound in the woods.

Distance from mouth, by the river 130.3 kms., in straight line 52.35 kms. Distance travelled to-day 40.8 kms.

Aug. 25rd.--Camp. Kms. 130.—The river fell 11 cms. in 15 hours.

Very characteristic are the lagoons and marshes which reach within a few metres of the top of the bluffs, being separated from the river by longitudinal ridges, so that with a little spade work they could be made to drain into the river. They are lagoons which maintain a level of 5 to 6 metres above that of the river at its present height and in some parts have a very considerable area.

In the steep banks in those parts, there are filtering strata through which the water percolates into the river.



It might perhaps be possible to utilize these lakes for feeding the river in times of drought. A study during some years and the measurement of their extent and depth, would be necessary to throw light on the problem.

The considerable diminution in the volume of water noticeable in proportion to our progress upwards, is a proof that these marshes must discharge into the river at points that we have already passed lower down, so it is quite possible that their regulating influence in the lower part of the river would be lost in the event of forcing their discharge into the river at a point higher up.

The subsoil is very little permeable, so the great mass of water

in those extensive lakes and marshes gradually diminishes by evaporation and by slow filtration towards the deeper bed of the river.

12 noon. Fort Altamirano.

SOUNDINGS.

Section Sol 48, Max. depth 3.60 ms. (Sol 0.60), kms. from mouth 134
 » » 50, » 4.30 » (» 2.03), » » 138

We began to see some red quebracho trees. The bluffs contain more loam which is favourable to the growth of these trees.

There are many "raigones" (roots of hard wood trees embedded in the river).

The ridge on the sides follows the river like a very pronounced longitudinal embankment.

SOUNDING.

Section Sol 56, Max. depth 5.00 ms. (Sol 0.80), kms. from mouth 150

The red palm tree abounds here, it is inferior to the black palm, its wood being less resistant.

5.15 p. m. Camp km. 168.

Distance from mouth.....	157.7	kms.
» in straight line.....	62.35	»
» traversed during day	28.00	»

On arriving at the encampment, the engine of the steamer got out of order, not being accustomed to work so many hours at a stretch.

Aug. 24th.—Beautiful clear weather.

Velocity of the current observed was equal to 63 centimetres per second.

After having got the engine into working order,—the skipper having acted the part of diver,—we started at 9.55 a. m.

Forcing the engine to the utmost we attained 8 kms. per hour or 4.4 miles with all the tow.

SOUNDING.

Section Sol 65, Max. depth 2.75 ms. (Sol 1.29), kms. from mouth 172

The river is narrower with more embedded roots in the channel and fallen trees on the banks. These are not so high over the water level—about 4 metres—and show more compactness in the concave curves.

12 noon. A rapid of minimum depth.....	2.85	ms.
1.45 p. m. A rapid » » »	1.90	»

SOUNDING.

Section Sol 68, Max. depth 2.15 ms. (Sol 1.45), kms. from mouth 181

The water in the river is of a dirty yellow colour which makes it difficult to distinguish the embedded roots a few centimetres from the surface. There are indications that the freshet rose 5 metres above the present level.

5.50 p. m. *Laguna de las Palmas* and Camp.

Distance from mouth	191.5	kms.
» in straight line	75.70	»
» traversed during day	34.00	»

Aug. 25th.—Fine weather.

The river fell 12 centimetres during the night.

The lagoon *Las Palmas* has communication with the channel of the river by a short brook and receives on its N. W. side a small affluent; it is 400 metres long by 200 wide. Its waters are like those of the *Pilcomayo*, dirty and brackish and is full of small fish, many of which leaped into the boat. There were many aquatic birds on the shores.

To the north and south there are extensive palm forests.

We have not yet had any difficulty in finding potable water; in the lagoons and pools behind the longitudinal ridge there is fresh water.

6.25 a. m. We passed out of the *Laguna de Las Palmas* and at 7.40 arrived at "*Junta de Fontana*" where we halted to determine the volume of water in the two branches and to observe the geographical latitude (24°, 56', 14 S).

Distance from the mouth	197.00	kms.
In straight line	77.50	»

The water in the southern branch was 21 ms. broad with a maximum depth of 3 ms. and a volume of flow of 18 cubic metres per second; the northern branch having a width of 19 metres, a depth of 2.70 ms. and a volume of flow of 12.50 cubic metres.

The bank of the southern branch was 3.14 ms. above the surface of the water, which has reached a height of 3.30 over the top of this bank, in time of high flood, from which may be gathered an idea of the enormous volume of water that comes down in times of extraordinary freshets.

The water in both branches is of the same colour and similar as to brackishness. Fish abounded especially at the junction, where we easily secured a great number of "dorado" fish of more than 50 cms. length.

1.45 p. m. We continued our journey on the southern branch, which became narrow and full of remains of submerged trees and trunks of trees lying horizontally from the banks which had been undermined by freshets; thus rendering our progress very difficult.

SOUNDINGS.

Section Sol 77, Max. depth 2.70 ms. (1.46 Sol),	kms. from mouth	202.4
» » 78, » » 2.25 » (1.84 »), » » »		206.8
» » 79, » » 2.50 » (1.26 »), » » »		209.6

4.45 p. m. Camp.

Distance from the mouth.....	209.6	kms.
Straight line.....	78.75	»
Distance travelled during day.....	19.1	»

We still had enough water to navigate in, but progress had become very difficult in consequence of the "raigones".

Father Guido de Petri here overtook us in his steam launch, still bent on finding a route by the river to his mission in Tacagl .

He is one of those enterprising clerics who with his robe twisted round his loins and a traveling cap covering his scarcely visible tonsure, faces the hardships of travel in the Gran Chaco to open a way for civilization to those deserts, by means of an active commerce in the products of the country, as well as by the narrow and difficult path of the gospel.

Father Petri said that the night previous they had seen a large tiger, which quietly gazed at them from the bank but disappeared before they could get ready their fire arms.

Aug. 26.—The river continues to fall.—5 centimetres during last night.

SOUNDING.

Section Sol 80, Max depth 2.75 ms. (1.39 Sol),	kms. from mouth	211
» » 81, » » 3.— » (1.39 »), » » »		215.4
» » 82, » » 3.— » (1.25 »), » » »		218.2

On both sides there are very low lands separated from the river by well pronounced ridges which are clad with high trees and cut by brooks that fall into the river. The bed of these brooks is generally on a level with the normal height of the water in the river, rarely lower, this being a very important feature for the natural regimen of the river flow.

11.30 a. m. We passed the Arroyo Dulce which comes from the south bringing excelent water, and at 11.40 we suddenly per-

ceived in a lovely bend of the river, an argentine flag on a tall cane stuck in the bluff. It was enthusiastically saluted and carefully removed from the edge to a more secure place on the shore. We at once climbed the bluff in search of the person who had placed it there. We found the Father Donato Ferry, franciscan missionary, who with two men and two indian guides was waiting for Father de Petri—he had made a good cart road from the Tacaglé Mission and had two carts with him.

This is a beautiful spot suitable for a port, with a deep water cove and high pasture land with many palms and some large quebrachos.

SOUNDING.

Section Sol 86, Max. depth 2.50 ms. (0.33 Sol), kms. from mouth 228.3

4.20 p. m. River Lobos from the south, broad and deep, which possibly is the entrance that Father de Petri is looking for.

SOUNDING.

Section Sol 90, Max. depth 2.55 ms. (1.26 Sol), kms. from mouth 236

The course of the river improves somewhat; not so many sharp turns, little current and fewer "raigones".

5.40 p. m. -- *Camp.*

Distance from the mouth..... 238.6 kms.

In straight line 90.— »

Distance travelled during day 29.— »

August 27. - The river fell 8 centimetres in 14 hours.

8.55 a. m. We started, after having spent some time in finding dry hard wood fuel for the steamer.

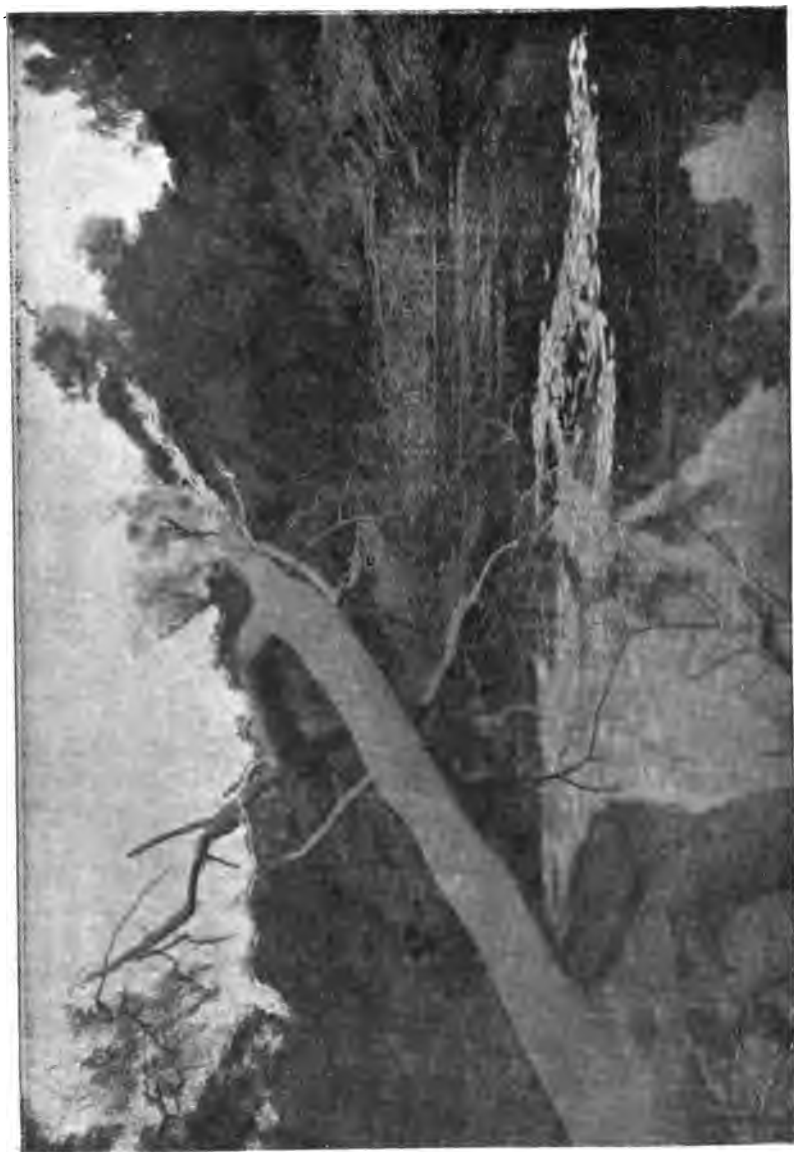
The banks which here begin to be covered with *carizo* (*L. Panicum leucophaeum*) down to the water, are lower, 2.50 to 3 ms., and the fields more open, with extensive groups of palms.

The high freshets here have not reached much over the top of the banks.

10.50 a. m. We passed the Las Palmas rivulet, affluent from the S.W. with fresh water and a strong current.

Soundings at the mouth of this rivulet gave 2 metres, somewhat further up stream 1.75 metres, and in the Pilcomayo at the junction 2.30 metres.

The men of our party who had some familiarity with the country to the north of the Tacaglé Mission, said that this river unites with rivulet and marsh Ñacucaldá.



Lower River Pitomayo. — Dead fishes.

At 247 kms. (from the mouth) we found only 1.25 ms. depth, the bed of the river having silted up owing to the trunks of some large trees which had fallen in.

3.30 p. m. The "Toldería" river with fresh water and little current.

SOUNDINGS.

Section Sol 96, Max. depth 1.45 mts. (1.85 Sol), kms. from mouth 248.4
" " 97, " 1.50 " (1.85 "), " " 250.0

4.15 p. m. "Caranchos" river and soon after encampment, which might be called "Separation Encampment" on account of the decision there arrived at, to send back the steamer "Progreso" owing to the scarcity of water and the tendency of the river to fall.

As may be seen from the comparative soundings, we had found lesser depths than those recorded by the engineers Sol and could estimate from the observations taken every morning that the total fall since the 20th of August amounted to more than a metre.

There is an enormous quantity of fish in the river—big "dorados" so tame that they allow themselves to be killed with a knife or harpooned with the surveying rods.

Encampment Separation.

Distance from the mouth 250.6 kms.
In straight line 95.1 »
Distance travelled during day 11.0 »

August 28.—The river fell 8 cms. in 11 hours.

After having prepared report and letters and sent off the two men who comprised the crew of the "Progreso", down stream, we started at 6.20 a. m. on our voyage up river, propelling the boats with oars or poles. We now saved the time required for cutting fuel, being for the future forced to rely on our arms for locomotion.

Towards N and S there are extensive marshes covered with "totora".

The water of the adjacent low lands percolates into the river through the banks which are about 2 metres above the surface of the water. The river in certain parts is only 15 ms. wide at the surface, with considerable depth in these narrows where the great obstacle to navigation consists in the numerous "raigones".

The water here begins to be very salt and full of dead fish—probably on account of the sudden fall in the river or owing to some epidemic. A penetrating smell of fish is felt all over.

SOUNDINGS.

Section Sol 98, Max depth 1.00 m. (1.95 Sol), kms. from mouth	251.9
" 93, " 1.00 " (1.66 "), " "	254.6
" 100, " 0.75 " (0.21 "), " "	258.4

We passed the night near a stream of fresh water marked by engineers Sol.

The big boat lagged behind and only reached our camp the next morning.

Distance from the mouth.....	260 kms.
In straight line	101.2 »
Distance travelled during day	10.0 »

August 20.—Morning broke cloudy after rain during the night, the river having fallen 2 cms. in 17 hours.

The big boat arrived at 9 a. m. having had to contend with numerous "raigones" and shoals.

The soil in the fields here is sandy on the river banks, and further out generally muddy with little vegetable matter; must be easily subject to inundations to judge by the quantity of remains of shell fish found on the banks.

Having arranged our cargo, placing as much as possible in the small boats, we started at 1.25 p. m.

The banks keep low, 1.50 to 2 ms. above the water, the woods not so well grown, with palms scanty and dry.

SOUNDING.

Section Sol 102, Max. depth 1.00 m. (Sol 2.62), kms. from mouth 261.6

6 p. m. Camp.

Distance from the mouth.....	266.5 kms.
In straight line.....	105.80 »
Distance travelled during day	6. »

August 30.— Cloudy night with a few drops of rain. very damp.

River fell 1 2 centimetre during the night.

6.30 a. m. We started from km. 266.

Palms becoming scarcer, there are no big trees.

The river presents longer reaches and what is characteristic, generally of greater breadth and depth with less current. The slopes of the bluffs are less abrupt and show fewer fallen trees.

The stink from the dead fishes increases; the water is putrid and full of maggots; which makes navigation very disagreeable, as the crews of the boats have to get into the water frequently and for long at a time.

8 a. m. Km. 269 and Arroyo del Salto (Waterfall brook).

At km. 273 the velocity of the current about 0.88 m. per second (1.7 miles per hour).

The immense riches in virgin forest reported by Storm, not yet noticeable; there are *timbó*, *aliso* and a species of *lecheron* without the two characteristic knots at the base of the leaf.

Everywhere there are signs of the great freshets which nearly covered the bank of about 2 ms. above mean water level.

4 p. m., km. 280. From the Argentine side comes a fine stream of fresh water which runs into the river over a fall and is not marked on Sol's map — probably the bank was cut through subsequently.

SOUNDINGS.

Section Sol 103, Max. depth. 0.87 ms. (Sol 0.52), kms. from mouth	263.0
104, 1.00 : (0.52),	264.6
" 106, 0.75 (" 0.67),	268.3
" 108, 0.75 : (" 1.—),	270.9
" 112, " 0.75 " (" 1.75),	279.0
" 113, " 0.75 " (" 1.89),	280.3
" 114, " 2.25 : (" 1.—),	281.8

5 p. m., 282.9 km. and Camp.

Distance in straight line from the mouth.. 116.85 kms.

" travelled during day..... 17.—

August 31. Km. 282.9. - Fine weather.

The river fell 1 cm. during the night.

At 6.15 a. m. we set out, and at 7 o'clk perceived an indian trail, narrow and tortuous, and a raft of "totora" for crossing the river.

The banks here become higher, up to 3 ms. above water and firmer with less sand and more clay, with traces of white "tosca", still soft, at the base.

It is characteristic that in all the distance traversed, with Sol's map before me, I did not notice any great change in the curves of the river, not even in the sharpest turns and bends during the 15 years that have elapsed, which affords grounds for supposing that the consistency of the banks and the support afforded by the trees, have been sufficient to withstand the destructive force of the freshets.

The river continues to run in long reaches, deep and broad, which, presumably owe their origin to ridges of harder material which stretching across the bottom, dam up the water.

10 a. m. Km. 294. From the northward there was a stream of fresh water, already vitiated by the dead fish, and where it falls into the river, the few fishes that were still alive eagerly sought the less brackish and putrid water.

We named the place Rotten Brook, and little being wanting before reaching the limit of Sol's survey, we remained long enough to determine the latitude by solar observation.

The velocity of the current noted was 0.32 metres per second (4/5 mile per hour).

The height of the banks was 3.86 ms.

SOUNDINGS.

Section 116 Sol, Max. depth 1.00 m. (Sol 1.55), kms. from mouth	285.4
» 117 » » 1.25 » (» 0.52), » »	288.2
» 118 » » 1.25 » (» 1.12), » »	289.7
» 119 » » 1.75 » (» 1.37), » »	292.3
» 120 » » 0.75 » (» 0.96), » »	294.5
» 121 » » 0.75 » (» 0.93), » »	296.5
» 122 » » 0.75 » (» 0.43), » »	297.9

4 p. m., km. 298, terminal point of Sol's map, NE corner of the property of Mr. Nicanor Godoy, adjoining the lands of the Franciscan Mission. S Lat. 24°, 26', 20".

I marked the point by having two large surfaces cut on a large "timbó" tree and commenced, by means of Palacio's telemeter and magnetic directions, the plan of the course of the river.

6 p. m. Km. 300. Camp.

Distance in straight line from the mouth 126 kms.

» travelled during day..... 17 »

We passed the night without water, not having been able to find any fresh enough to drink in the neighbouring marshes.

Further on in this report the accumulated distances and other detailed data concerning the course and bed of the river will be presented in the annexed synoptical statement, with the use, as a starting point, of the mouth of the river for the kilometric distances.

September 1st. Kms. 300 to 309.

At noon we reached the abandoned Franciscan Mission, distant kms. 134 in a direct line from the mouth of the river, situated in an open plain, level and grassy; provided with a good draw well and ample dwelling house, constructed of palm trunks. In the



Lower River, Pitomayo — Baradero.

neighbourhood there is a good deal of red "quebracho" wood and in the kitchen garden we found still some bananas, cotton and vestiges of maize plantation.

The brooks which fall into the river Pilcomayo had almost all fresh water; an exception being one on the Paraguayan side, which we passed in the afternoon.

September 2nd. Kms. 309 to 321.

Onwards from the abandoned Mission, where begin the long straight reaches in the river, the land appears to rise somewhat and seems drier.

The vegetation also changes, and one can notice the difference pointed out by Mr. Storm,—higher forest trees and these of harder wood: *quebracho*, *jacarandá* and *guayacán*.

The river seems to preserve its gentle incline, divided into long reaches with little fall and separated by parts of less depth but greater fall—rapids.

Such parts flow over a bed of more solid earth and of more compact "tosca". Without a longitudinal levelling it is difficult to get a proper idea of their relative elevation.

September 3rd. Kms. 321 to 329.

From the bottom and at the water's edge, there are numerous very salt springs, which give the river its brackish taste.

September 4th. Kms. 329 to 336.7.

The difficulty of navigating increased: frequently we had all to get into the water and after hard struggling would succeed in getting the big boat over the "raigones" and across extensive shoals—a by no means pleasant task, considering that the foul water was swarming with dead fish full of maggots.

September 5th to 15th. Kms. 336.7 – Baradero (24°, 38', 46" S).

Pondering over the position of our expedition and the distance traversed, compared with what remained before us, I arrived at the conclusion that it was absolutely necessary to reform the big boat so as to make it lighter, and the idea occurred to me to make two boats of it, by sawing it in two and putting a bottom on the upper half. In this way we would have two boats, each of 800 to 1000 kilos weight, which we could drag, in case of need, after emptying them.

There was no time to be lost. On the morning of the 5th we started work after searching in the adjoining forest to find wood for the ribs and planks for the bottom. Mr. Cáceres was put in charge of the improvised saw pit, whilst I acted as carpenter. We put

strong "lapacho" ribs and "palo blanco" bottom in the new boat, which was 11 metres long and 2 1/2 wide, with a superficies at the bottom equal to 19 square metres.

The work occupied 10 days, the want of appropriate tools--especially suitable saws and planes--causing much delay.

The weather was good during these days, partly cloudy with a little rain, and the river fell in all, 7 centimetres.

We noticed a change, little by little, in the water of the river and the number of dead fishes grew smaller; the water itself became gradually darker, the deep pools seeming as if they were of black ink. So strong was this black colouring that white cloths and ropes immersed in it were perceptibly dyed. Simultaneously the bottom of the river was being covered with a fine sticky black slime having the smell characteristic of the stagnant water in the marshes and lagoons. At first we could not account for this change in the water, but eventually supposed that the black slime came from the "totora" in the marshes, burnt during the dry season; this supposition being confirmed later on when we arrived at the Estero Patiño. The presence of this black stinking water certainly did not render travelling on the river more pleasant.

We had not yet found much difficulty in procuring potable water, because at intervals there were rivulets with fresh water from the marshes near.

On the 14th September we finished the carpenter work on the new boat, and on the 16th the caulking.

September 16th. Kms. 337 to 340.

I made a short excursion towards the SE to examine the country, cutting a path as far as 1 1/2 kms. from the river. The high land on the bank of the river, covered with big healthy quebracho trees is very narrow, only from 200 to 400 metres wide, after that, lower land, very muddy, with low shrubs among scattered trees, in poor condition or dried up.

We found red *quebracho*, *palo blanco*, *guayacán*, *lapacho*, *ñangapiri* with ripe fruit, and further to the south, abundance of white palms. To the north of the river at this part the zone of high woods is more extensive.

On our return from this excursion we launched the new boat, and had the satisfaction of seeing that it leaked less than we had expected. It was a joyful moment, as we all understood the importance of the result we had achieved.

We started in the afternoon with a cloudy sky and drizzling rain. The new boat went well but leaked so much as to render it



Lower River Pitomayo - Baradero,

necessary to bail day and night, this however not being any great inconvenience as it was imperative to keep watch every night for the security of provisions, implements, etc.

September, 17. Kms. 340 to 347.

Weather cloudy—drizzling.

River with tendency to fall.

The new boat behaving well; it has become flatter of itself, and with its load draws only 25 cms.

Here is much quebracho and other hard wood (jacarandá) on the ridge, especially on the Paraguayan side.

The "raigones" and the rapids cause much trouble; we are working in the water all the day.

September 18. Kms. 347 to 353.

Fine weather.

The river here runs in a deep bed between high bluffs, in some places 7 ms. in height, consisting of somewhat hard "tosca" which forms falls and rapids.

I observed the latitude for the purpose of fixing that of the encampment Baradero.

September 19th. Kms. 353 to 358.

We began to notice a difference in the colour of the water, which became less dark and brackish. The bank continues to be covered with good wood, much quebracho and "jacarandá".

From the encampment Baradero up river the "raigones" were almost continuous.

We found the trunk of a thick tree that had been cut with a saw, and also in one of the rapids a piece of fossil bone.

September 20 th. Kms. 358 to 361.

On both sides there are small cañons and rifts through the banks, about half way from the top. We have now only two days supply of jerked beef and on account of the rapids and "raigones" we make little daily headway. In the rapids at km. 360 we required three hours to get through, after having provisionally dammed the river in order to raise the level of the water.

September 21. Kms. 361 to 366.

We continue to come across shallow rapids, generally caused by reefs of tosca which cross the bed of the river. This tosca in some parts is very hard, almost like sandstone, and is, as may be supposed, a feature of great importance in the canalization of the river, as it would provide, in suitable places, foundations for locks.

Above the rapids there are reaches, longer and deeper, so that the inequalities of level are concentrated at those points of harder bottom.

At varios points we came across trunks of trees cut with saw by preceding expeditions.

September 22nd. Kms. 366 to 371.

We continued struggling with roots, rapids, shoals and want of water, so that during the day we advanced only 5 kms.

Towards the west we observed clouds of smoke and thought it might be Mr. Casanova who was firing the dry "totora" in the Estero Patiño. Later on we found that we had not been mistaken.

The water of the river now begins to be clearer and less salt, the bottom being still very dark on account of the deposit of black slime.

September 23. Kms. 371 to 376.

The banks continue high, and in the plains beyond are seen big patches of pasture and extensive palm groves.

The high land on the borders of the river continues to be covered with hard wood trees, quebracho and "guayacán", more "alisos", being observable near the lower part in line with the "chilca" (*Baccharis salicifolia*).

We saw many wild birds, "charatas" and "torcasas".

The question of drinking water presented many difficulties.

During the continuous fall of the river we generally found enough slightly brackish water in small wells which we dug in the sand near the edge of the shore; this was the fresh water coming through the banks on its way to the river. Once the water in the river became stationary, this source of supply ceased, and we had to fall back on water more or less good, which we found in pools in water courses which discharge into the river.

We also availed ourselves of the water retained by the leaves of the "caraguatí", a kind of cardus, which the men, rendered desperate by thirst, sought with avidity.

September 24th. Kms. 376 to 380.

The river water began to be less salt, becoming almost potable.

I made a short excursion into the woods on the Argentine side; the ridge here being rather wide. In the distance towards the south could be distinguished the towering branches of quebracho trees.

We began to have an idea that "Junta del Dorado" could not be far distant and so it turned out. As chance would have it, we chose for our encampment a spot near the mouth of a small, dry



Junction of the River Pihomayo and Arroyo Dorado.

water course, on the southern bank of the river, where we found foot marks,—Mr. Casanova and his men, who had come down to the river and gone back again.

September 25th. Kms. 380 to 382.

Some rain last night.

We followed the trail of Casanova as far as the traces of his camp in an open plain, which had been fired some time previously. There was good pasture, but no water.

Not finding any signal or mark we went on up river in the boats, and shortly came across a man who had been sent by Casanova to look for us; his party had heard the shots we fired when we discovered his trail.

Furnished with provisions and greetings to his chief, he went off and soon after appeared Mr. Casanova who told of his sufferings from want of provisions and the hard work entailed by constantly having to keep his live stock together. He had reached "Tapera Bailon" on the 13th September.

At noon we arrived at the much longed for "Junta del Dorado", which turned out to be a great disillusion: a broad watercourse, equal more or less to about half of the valley of the Pilcomayo, contributed an insignificant stream of water, of the same taste and colour as that of the Pilcomayo.

The banks are high, and in great freshets the Dorado must carry a large volume of water.

To the south of this stream there is a narrow strip of quebracho trees, and beyond this, comes open plain with palms and mounds with hard wood trees. This strip of quebracho trees, according to Mr. Casanova's opinion, is of variable width, of a mean of about 1 kilometre.

The guides who had been engaged and should have come with Mr. Casanova, had not made their appearance, with the exception of Bailón Benítez, former occupant of the "Tapera Bailón", who had already started in a westerly direction to notify the indians that we came with friendly intentions and only wanted to give them presents.

The first portion of our programme was now completed by the junction of the two divisions, at the point where the Estero Patiño begins.

September 26th.

Some rain this afternoon. A day of rest for the men and of study and preparation for the chiefs.

I made the calculations necessary to fix the point where we

were, and found a difference of 40 kms. compared with the map of Governor Luna Olmos.

I studied and compared the data of former explorations and in the afternoon made a reconnaissance on foot up the river Pilcomayo, observing that it remained the same, with "raigones" and rapids, these separating rather long reaches of greater depth and less current. Towards the south I crossed a dense wood, with few high trees, as far as the river Dorado which flows in a deep bed from the westward.

Mr. Casanova had reconnoitered several parts of the southern border of the "estero", between the "tapera" Bailón and the Junta del Dorado, and discovered according to his account, to the north of the "tapera" Ríos, a rather long channel which might be the continuation of the river Dorado, and although for my part I had no hopes of success, I yielded to the wishes of Mr. Cáceres to make the attempt to go up the Dorado in the smallest boat, being both agreed as to the impracticability of going by the river Pilcomayo, as this would take us too far away from our great support—the land convoy—and besides, because Mr. Storm in his exploration had failed in his attempt on the Estero Patiño, making use of this river, which probably at that time was higher than when we saw it.

September 27th.

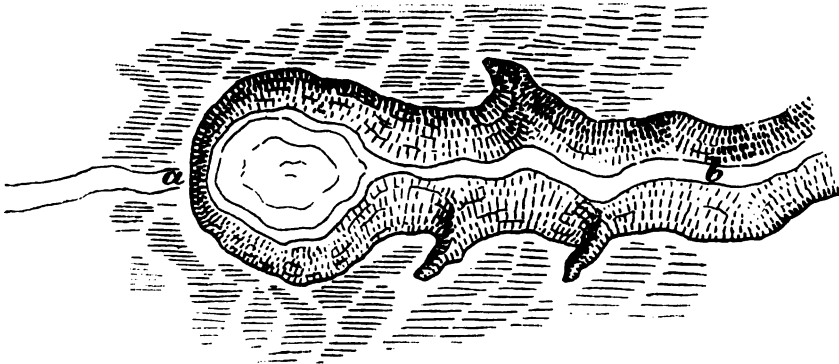
We started up the Arroyo Dorado, dragging the small boat, with provisions for 3 days, and six men, having previously, at daybreak sent Mr. Ayala with 6 men to clear the river, and where practicable, to raise the level of the water by making dams across the bed.

At first we went all right with the small boat, which was narrow and of little draft; but it would have been a hard task with the large boats. We reached a fork in the river where two branches, each with very little water, united. They were both full of "raigones" and rapids.

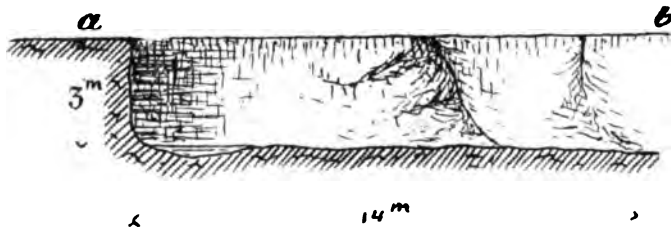
There was no use thinking of proceeding further with the boat.

We followed the northern branch on foot and after going about 800 to 1000 ms. found that it separated into various small affluents, ranging between 100 to 200 metres in length, which suddenly terminated in circular springs—well-eyes—with a depth of about 2 to 3 ms. below the level of the marsh, and the water gathering over the impermeable layer of clayey, yellowish "tosca". The humus of the marsh, of a grey earthy colour extends from these wells and tortuous cañons horizontally towards the west, covered with dry "totora" which in several portions had been burnt.

From these well-eyes we crossed over to the southern branch of the Dorado and found that this affluent has a like origin.



A spring—well-eye—of the Arroyo Dorado.



Vertical section.

The water of these springs is cool and sweet. Lower down the brooks receive rills of salt water in varying quantities, so that one can discriminate between the flavour of the little affluents, whose springs are separated by only short distances, of about 200 to 300 metres.

The drought must have been exceptional, as the ground in the marsh was completely dry and only muddy on the edges of the little brooks, in which innumerable fishes were crowded together for want of water. Numerous aquatic birds and also buzzards took advantage of the precarious condition of the poor fishes, the surface of the pools being quite black on account of the backs of the "sabalos"; there were also "dorados", but not so numerous; we got all we wanted by shooting them or sticking them with knives.

Every where we saw tracks of tigers, who are eager fishers and according to indian accounts make use of a ruse, ejecting froth from their mouth on to the surface of the water in the little pools and then seizing with their claws the fishes that pass under the froth.

Deer are frequently found in the woods on the borders of the marsh—Mr. Casanova's party having killed several.

On our return from the springs of the "Arroyo Dorado", we crossed the indian path that leads to "Salto Palmares" and we decided, Mr. Cáceres and I, to make an excursion to that point to explore the course of the river Pilcomayo.

At night I determined the geographical latitude of the "Arroyo Dorado".

September 28th.

We left on mule back passing the "Arroyo Dorado" at the fork before mentioned and following the indian path we crossed a fine tract of country with good pasture and isolated mounds clothed with tall trees; and after 2 1/2 hours of travel along the border of the marsh, covered with palm trees, we arrived at "Salto Palmares", or rather, the place where the fall was last year, indicated by a tablet, bearing the initials of Ulpiano Cáceres which was nailed there when he accompanied the Governor Luna Olmos. We were astonished to see that the fall was no longer there; a freshet, probably the last one, had broken away the ridge of "tosca" in the river bed that caused the water fall, forming a short rapid between the upper hollow and the one down stream on the other side. In the upper part of the river there was produced a fall in the level of the water, and consequently at the upper end a new fall had been created, which we found 200 ms. higher up from the old fall.

A sketch shown on the accompanying map gives an idea of the shifting of this Palmares fall.

Down stream from the old falls the banks are about 4 ms. above water level; but gradually they become higher up to from 7 to 8 ms. at the confluence with the Dorado.

An approximate calculation of water passing over the fall gave about 200 litres per second.

This erosive action of the water also explains how it was that Mr. Cáceres in his previous visit to the Palmares fall, could not find the sign put up by Mr. Storm, which probably had been set up more to eastward, close to the falls which then existed.

The river manifests a tendency to gradually lower its bed towards the west. Taking into account that a like action of the water exercises an equal influence in the affluents of the river Dorado, where the freshets bring down the surface earth from the marsh, and that the springs before described are located always more and more to the westward, it may be easily understood how important are those factors for the future aspect and configuration of the region of the marshes.

Further on I shall revert to this subject, but now continue the narrative of our excursion.

As in the Arroyo Dorado, we noticed in the Pilcomayo a great many fishes crowded together in the deep pools.

We followed the border of the river up stream, mounted or on foot as we best could, concentrating our attention on the discovery of the different water courses, which Mr. Storm tried to go up in his heavy boats.

The marsh being dry and the reeds in part burnt down, we had the good fortune to be able to study and verify in less than one day the hydrography of the river Pilcomayo in the identical places where the explorer referred to, was detained for more than a month, precisely because the level of the water in the marsh was then too low for navigating and too high to permit of exploring on foot, the marsh being muddy and intransitable.

Proceeding up river we noticed at intervals small rapids over hard "tosca" and a gradual diminution of the volume of water, the banks also diminishing in height, until the former comes on a level with the lower part of the bulky roots of the "totora"; whilst at a distance of 3 to 4 kms. above the fall, the river begins to split up into small branches which gradually disappear on the surface, on ground as a rule very boggy, the last sources being about 10 kms. from the Palmares fall.

We had verified therefore a complete interruption in the course of the river Pilcomayo in these parts, and remembering the indian tradition that at a short distance westward the river reappears, and besides it being impossible to go further on in the mud, we decided to return in order to make a circuit along the edge of the marsh and attempt to penetrate it more to the westward.

We had some trouble in getting our mules out of the marsh. Going in a north westerly direction we crossed through openings in the palm groves where we were surprised to observe from the direction the fallen reeds lay in, that the current of the water in times of freshets must have been in this place from N. E. to S. W.

We passed the night on a fairly dry spot under the palms.

September 29th.

We continued coasting the marsh, and going towards some green reeds which we espied to the S. E., we crossed some broad dry channels, experiencing the impression that the ground rose gradually towards the west, and again found running water, that came from the W. N. W. and which continued to augment as we went along the border up river.

All the land was very boggy, the level of the water being about 50 cms. from the surface of the ground; in the expanse of reeds there were well pastured spaces on somewhat higher land.

I determined approximately the volume of water in the stream which we had discovered, the current being very sluggish, 10 cms. per second, the section under water being 7 ms. wide by 0.60 ms. maximum depth, equivalent to a flow of 150 litres per second.

The bottom is hard with a thin layer of mud, as is generally the case with all the brooks and streams of the marsh. In these we find, in many parts, old trunks of hard woods trees, such as quebracho, algarrobo and guayacán.

We had reached the point where the Pilcomayo disappears into the marsh, losing its waters in the porous strata that lie over the plane of impermeable "tósca" almost horizontal with the height of the crest of the Palmares fall, which in its turn works continuously to move towards the west, traversing little by little in a deep bed, all the length of the great marsh.

It may be that this disappearance and reappearance of the waters is repeated as far as the limit of the plane more or less horizontal of the marsh, although this would not accord with the reports of the indians that the water further up does not cease suddenly. Our subsequent discoveries showed that those reports were not true.

It is supposed that formerly the marsh was a great lake formed in an extensive and almost horizontal depression in the impermeable strata of "tósca" and that in time it was gradually filled up with the detritus brought by the streams that now fall into it, as into a great sponge to emerge from it by the Arroyo Dorado, the southern branch of the Pilcomayo and probably by the northern branch also, besides by other streams and rivers more to the north.

The fact of finding trunks of hard wood trees at the bottom of the broad water courses in the marsh, may be accounted for by supposing that when formerly the level of the marsh itself was lower, the higher ridges or undulations of the impermeable strata gave rise to the formation of islets or mounds, where the trees grew. As gradually, owing to the great freshets the general level of the marsh was raised and those high spots were covered with muddy deposits, the trees died, and later on the currents had cut through the softer upper layers and once more exposed these trunks, vestiges of an extinct vegetation.

As shown above, nature herself undertakes the gradual emptying or draining of the great marsh and presumably there is a possibility of accelerating the regulation of this great work, assisting nature

to deepen the present water courses by taking advantage of the difference of level between the bed of the river Pilcomayo at the Junta del Dorado and the western portion of the Patiño marsh, where, as we shall see later on, there are again to be found channels and streams with banks, in part, high and well defined. For this however, careful studies and ample data respecting levels would be necessary to elucidate and resolve the problem.

On returning from our excursion we wished to cross towards the south by the Isla de Palmares as far as the streams on the southern border of the marsh, but we found the ground too soft, the mules sunk into the mud and it was with great difficulty that we got them out, so we were obliged to go round by the Salto and the Horqueta del Dorado. We returned late to our encampment in the Junta del Dorado, well pleased with the results of our reconnaissance although somewhat perplexed by the thought as to how we would be able to carry our boats further.

September 30th.

As the marsh was dry what could we do? What road could we take? Firstly we had to give up the idea of taking the two large boats with us, limiting ourselves to finding a means of transporting, without losing too much time, the four light boats to the channels and streams explored during the expedition of Governor Luna Olmos, and by which, according to the indians, the explorer Ibarreta had come down.

The course of the river Pilcomayo itself did not suit us, inasmuch as it took us too far away from our land convoy and its exploration was of less practical importance for the special object that we had in view, than the deliberate survey of the southern portion of the Estero, close to high and firm land. We had to decide for the course of Dorado, and to try by all means to carry the boats as far as the water course or rivulet Caldá further up than the last encampment of Ibarreta, bearing in mind that Governor Luna Olmos last year had gone with a cart as far as the lagoon Grande Final, somewhat to the south of a big river to the westward of the Estero Patiño.

In view of the above considerations and data, I decided on the following plan of operations: to place the boats on the cart to carry them as far as the "tapera" Bailón, at the same time improvising pack saddles for the mules for the conveyance by land of baggage and provisions; to study during this journey the region of the Patiño marsh and if the Bailón channel proved unnavigable towards the west, to continue the journey by land to the Paso Caldá

We proceeded to make suitable alternations in the high bank to provide a slope, up which we raised our boat "Estrella del Canal", placing it on the cart. All went well and in the afternoon the first contingent started with the boat and some bags of flour.

One circumstance greatly favoured our enterprise: the two guides Bailón Benitez and Bernardo Ríos, appeared, each with his cart both of which naturally were at once contracted for transport. These two men live in the most advanced posts towards the west and occupy themselves in collecting produce from the indians, both speak a little of the "pilagas" dialect and have indian wives. Before they had lived in the "tapera" (hut) Bailón y Ríos marked on the annexed map, but last year they withdrew towards the east from fear of the Indians.

I determined the latitude by solar observation, which agreed well with the stellar observation on the 27th September, and in the afternoon I went to ascertain the volume of the stream in the Pilcomayo and Dorado and to commence the construction of the polygon and level from the Junta del Dorado as far as the fork in the stream and the springs in the marsh.

The observation of the volume of water gave, for the Pilcomayo above the Junta, 0.577 cubic metres per second and for the Dorado 0.138 cubic metres, a total of 0.614 cubic metres.

October 1st—Junta Dorado, Lat. 24°, 27', 57" S.

I finished the observations of level as far as the springs of the Arroyo Dorado and also somewhat within the limits of the marsh, a tedious task in consequence of the density of the reeds; following this up at once with the telemetric survey, as far as a point in the cart road to the "tapera" Bailón.

The result of the levelling showed a total difference of 9 ms. between the surface of the water at the Junta Dorado and the level of the marsh to the westward of the springs of the Arroyo Dorado, the bottom of which is from 3 to 4 ms. below the marsh.

October 2nd. Junta Dorado.

It rained in torrents all last night, and continued raining part of to-day.

The river which during the last few days had remained stationary, rose 15 cms. and fell as much in the afternoon, remaining as before, very low, probably at lowest of summer drought.

We continued preparing everything for the land transport; riding and pack saddles, establishing a depot down stream from the Junta Dorado, where I left provisions for one month and everything

not absolutely required for the studies, under the care and protection of two trustworthy men, well armed.

For the continuation of the journey, express orders were given to prepare provisions for 3 1/2 months at least.

October 3rd. Junta Dorado.

Cloudy, the river rose 2 cms.

In the afternoon the cart returned after a delay due to the condition of the roads which had been softened by the rain. The first boat was already in the cañon in the marsh, to the north of the "tapera Bailón.

October 4th. Junta Dorado.

Good weather, somewhat cloudy, the river rose 1 cm.

We completed our arrangements, and the second convoy started with 3 carts. I continued the telemetric mensuration of our route and the study of the southern border of the marsh Estero Patiño, passing the night at Tapera Ríos, km. 392.8, situated on an extensive pasture, with good water near the surface.

October 5th.

At 1500 ms. to the north of the Tapera Ríos, I discovered a deep channel or cañon with water, lying east to west towards the springs of the Arroyo Dorado, 15 ms. in width and over 1 m. in depth, without visible current. The brackish, yellowish water reached up to the stems of the reeds in the marsh. Towards the east the channel diminishes in width gradually and then bifurcates and scatters its waters, being navigable for small boats for about 600 ms. the principal branch reaching a wooded islet where it turns slightly to the right.

I continued the survey to the Tapera Ronco, where we passed the night on the borders of a small marsh with fresh water and an enormous quantity of mosquitos.

October 6.

In the afternoon I had measured the distance, kms. 416.7, as far as Tapera Bailón, passing through fields of fairly good pasture and sparsely wooded with palm and algarrobo trees.

In some parts we went along deep channels which form the water courses for the drainage from the adjacent lands into the marsh, and near Bailón we crossed the big salt marsh Parali, at the southern border of which we came across a small bog with abundant fresh water.

At the Tapera Bailón, there awaited us a commission of some 20 Pilagas indians from different camps in the neighbourhood; they had come to offer us peace and amity and at the same time to receive the presents that the guide Bailón had promised them in

our name. We gave them tobacco, handkerchiefs, fishhooks etc. and at our request they shot at a target with their bows and arrows. I must observe that I had expected to find greater skill and surety in this warlike art and that I consider the clubs of *jacarandá* or *palo santo* wood as more formidable weapons than their weak arrows of *castilla* cane, furnished with a point of hard wood, or rarely, with a thin piece of iron ground to an oblong form. A very few of them carry long lances of hard wood generally with an iron point that had previously adorned the weapon of some cavalry soldier.

October 7. *Tapera Bailón*. Kms. 416.7.

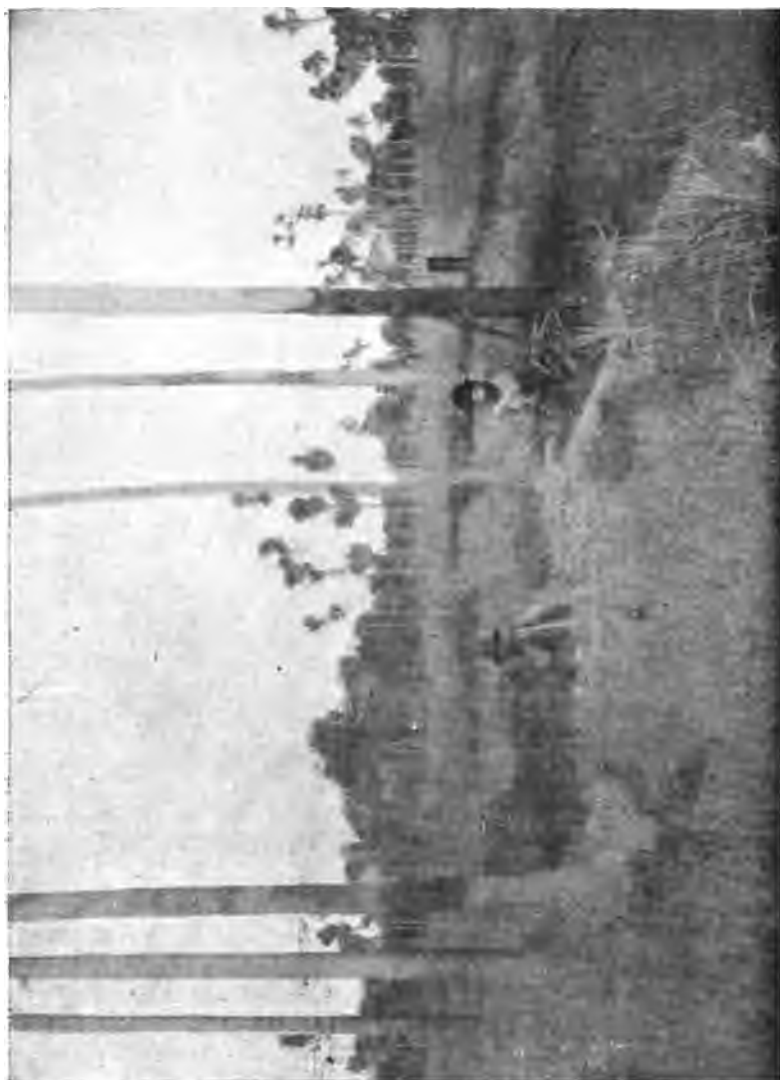
Having launched two boats in the channel to the north of the *Tapera Bailón*, we embarked with Mr. Cáceres to attempt to navigate towards the east and make a plan of the course. The channel was as much as 30 metres wide and was almost full of "totora" and floating masses of weeds (camalotes), with a maximum depth of 1 metre. With the light boats without freight, we advanced about 400 metres in an hour and became convinced that with the existing depth of water it would be impossible to take loaded boats up those trenches. We had to continue the journey by land until we found channels or brooks that were freer of impediments and of more continuous course.

Making use of iron climbing hooks such as are used by telegraph and telephone linesmen for climbing posts, I went up a palm tree and had occasion to appreciate the utility of such irons for reconnoitering purposes in those plains covered with rushes and "totora" (generally about 10 to 12 feet high) by taking advantage of any occasional dried up palm or other tree.

From the palm tree I observed that the fresh "totora", like a green fringe, followed the sinuosities of the edge of the marsh which was indicated by the palms, until lost to sight in the horizon. The same thing was noticeable towards the west, as also a band of darker colour which contrasted with the yellowish hue of the marsh, stretching in a north easterly direction towards the Palmares island. It may be that during the great freshets a big bend is formed in the principal current of the river, which then floods the marsh, and whose mass of water of greater speed seeks the most marked depressions in the soil.

I sent some men in that direction and they found that the depth of the water diminished to about 20 cms. and that the bottom continued very muddy.

It also appears that the island Los Palmares is connected with the higher land that forms the woody triangle of the Junta Pilcomayo-



Palm grove near "Tapera Ballón".—Eating palm tops.



Zouja Bula - Totoral

Dorado and that in this manner the great marsh is divided in two parts.

October 8th. Tapera Bailón.

In the early morning the weather became unsettled and later on there was a violent storm. After noon the weather cleared, and I took the level from the Tapera Bailón to beyond the water course of the same name.

On the annexed map I show the corresponding section. To the northward of the Bailón channel there is a low ridge running toward the N. E. which separates the channel from the above mentioned depression. A curious fact that became apparent from the observations of level, which were repeated to make sure, is worthy of mention. The level of the water in the marsh to the north of the above mentioned ridge was 16 cms. higher than the level of the water in the Bailón channel. This permits the supposition that along the south coast of the marsh there runs a natural independant water course separated from the main portion of the marsh, the existence of which may turn out to be of great importance for the problem of canalizing the river Pilcomayo.

October 9th. Tapera Bailón.

Cloudy cool weather. Whilst the transportation of provisions and other effects was going on, I started, accompanied by one man to inspect the southern portion of the marsh. The continuation of the Bailón channel is marked by the green colour of the "totora". To the north of the "Salina Parali" I made my way into the marsh and saw that there the channel was divided into two branches, respectively of 40 and 30 cms. in depth, with very muddy bottom, full of "totora", without any open channel and without any apparent current. One kilometre more to the eastward it appears, judging from the colour of the "totora", that the water of the channel has dispersed itself still more, forming a swamp where it unites with the waters brought by the water courses that drain the "Salina Parali" above mentioned and the lands to the south. In the attempt to cross the water course from the "Salina" we got into the mud in the channels or deep ditches. We had to work from noon to 10 p. m., with the water and mud up to the waist, being obliged to form a kind of bridge with the trunks of fallen palm trees, over the widest channel, in order to pass the exhausted animals over onto firm ground. We at once proceeded to skirt the borders of the "Salina Parali" as far as the cart road and after some searching in the dark, we found a pool with good water in a fresh water marsh to the south of the Salina.

October 10th.

Estero dulce de Parali (Parali fresh water marsh). Cloudy, weather cool. We returned by the cart road as far as the water courses of the "Tapera Ronco", where we left the animals and started on foot to inspect the marsh. Following a well worn path and passing several abandoned indian "tolderías", we arrived at a broad, deep channel with rather brackish water and without current, which proved to be the same one that we had come across to the north of the "Tapera Ríos". The surface of the water in the channel was some 20 cms. below the level of the marsh. There was abundance of fish and on the border were vestiges of the huts of indian fishermen. We called the water course "Zanjón de la Pesca" and returned late to the "Tapera Ríos",

October 11th. Tapera Ríos.

I returned to the water course which we had found, climbed several palm trees, and could see that the channel had been formed by two branches, one coming from the N. O., which perhaps is connected with the depression observed of the "Zanjón Bailón" towards the isle "Palmares", and another which inclines more towards the S. and probably derives its waters from the principal water course on the border of the marsh and from the drainage of the land. I waded up this branch towards S. W. It had, like all these channels a hard "tosca" floor, its width being 4 metres and depth 1 metre, which gradually in a distance of 400 metres diminished to 50 and 20 centimetres respectively, then being completely blocked up by "totora", among the roots of which a weak current from the W. was noticeable.

We returned slowly with the tired animals to the "Tapera Bailón".

October 12th.

I remained at the "Tapera Bailón" awaiting the arrival of our equipment and took the latitude of the place 24°, 24', 8".

October 13th. Tapera Bailón.

I started towards "Paso Caldá", collecting data for the plan of the route and arrived by noon at a little fresh water marsh about ten kms. to the W of "Bailón". In the afternoon I made an excursion in the great marsh in the direction of the "Isla Palmares" passing firstly over land slightly higher, salinitrous and pastured, and afterwards part of the marsh with greener "totora" and wetter soil, as far as about five kms. from the cart road, without coming across any continuous channel but only an insignificant local depression and a little spring similar in taste and colour to the water in the "Zanjón Bailón". More to the NE and as far as "Isla Palmares" the

marsh presented the yellowish colour which is usual in time of drought.

It appears therefore that in these parts the border water course which forms the continuation towards the W of the channel of the "Arroyo Dorado" is reduced to insignificant depressions.

October 14th. Estero Dulce.

We passed the "Estero de Yemtatandi", with the last encampment of the explorer Ibarreta, as far as our new general head quarters, located half a league down stream from the true "Paso Caldá" and on the border of the channel of the brook of the same name. This "Caldá" channel has here a varying width of 50 to 70 metres and depths that exceed 2 metres. As may be supposed there is little or no current.

Many indians came to visit us and we tried through interpreters to obtain information about the connection that might exist between the channel at our feet and the river Pilcomayo, as it comes from Bolivia and Buena Ventura.

It is very difficult to get anything clear out of the tales of the indians; they are incoherent, often contradictory and even intentionally equivocal, as we had occasion to experience when going towards the W by way of the Caldá brook.

Two indians declared that they knew where were to be found the remains of Ibarreta's boats; we followed them as may be supposed with great interest, and when we reached the spot they showed us some little indian canoes overturned on the bank.

Oct. 15. Paso Caldá. Kms. 438.

We made a reconnaissance by water down the brook as far as where it ended in a little typical marsh lagoon, with low and muddy banks, terminating in a short channel covered with masses of floating weeds and slime which the stream had carried down.

The bottom is of the hard resistant and impermeable "tosca" which has given rise to all the system of marshes and "totoraes", below which the waters continue their slow progress until, further to the eastward, they form the sources of brooks and rivers.

From the little lagoon mentioned above, we crossed on foot towards the N.E. in a direction towards the line of palm trees, over very wet marsh land and across very deep channels with the water, which had very weak current towards the east, up to our breasts. I climbed a tall tree trunk and saw that the marsh was green towards the E. and separated the island "Palmeras" from the firm land to the N.

In the afternoon I went along with Mr. Cáceres and Mr. Casanova

to visit the last encampment of Ibarreta, where the three crosses erected evoke in an expressive manner, the memory of the sad fate of that intrepid explorer.

Oct. 16th. Paso Caldá.

Cloudy, some rain during the night.

I went, accompanied by Mr. Cáceres and Mr. Mayer, by water up stream to get an idea of its navigability. We ascended the broad part of the stream without difficulty up to its termination 4 kms. from Caldá; here it receives a brook of 5 to 6 metres width and 1 to 2 metres depth, with little current, which comes from several broad expanses where we stuck several times, vainly attempting to find an outlet until at last a young indian made his appearance and directed us precisely to one of the streams which we had tried and found blocked by floating masses of vegetation. These we had to cut through and then found a narrower channel, where the water was 0.75 ms. deep, which brought us to a rapid over the soft "tosca" with only about 20 cms. of water in narrow channels. We proceeded, dragging the boat, until we arrived at more open reaches (9 kms. from Caldá) which slowly improve in the direction of Lagarik. In a distance of a few kilometres the banks rise in height from 20 to 50 centimetres to 2 metres over the level of the water, with a layer of soil full of roots and alluvial detritus.

Below, the hard "tosca" continues, being here of a grey colour, so that it is possible almost everywhere to cross the channels and streams without sinking into the bottom.

On both sides are swampy lands with "totora" in the depressions.

The trees most common on the bank or ridge of the stream are "lecheron", "sauce" (willow) and "aliso". At two to three kilometres from both sides may be seen the lines of high forests of "algarrobo" (carob tree, *ceratoma siliqua* L.) and, especially towards the south, "quebracho".

Fish abounded in this stream and could be caught with the greatest ease, inasmuch as they leaped into the boat when its white sides brushed against the reeds and shrubs on the borders; those then caught were killed by our young guide who bit them on the head.

October 17. Paso Caldá.

At night there was a rain storm, in the morning cloudy and cool.

As the Caldá stream was almost without current I used the morning to determine the constants of the current-metre. In the afternoon I constructed a map of the portion of the Estero Patiño

which we had gone over in order to study and decide upon our future route, taking into account the data supplied by former explorers and the information derived from the indians.

The two guides Bailón Benítez and Bernardo Ríos wished to return to their homes on the road to Clorinda, so we took advantage of this opportunity to send our last mail via the lower Pilcomayo.

The considerations, data and information which should enlighten our judgment when deciding on a route which would take us with the least effort to the borders of the so much wished for upper Pilcomayo river were, briefly stated, the following:

The Caldá channel, with its continuation to the westward ought to be considered as a prolongation, interrupted by the Estero Patiño, of the channel of the Dorado stream.

Governor Luna Olmos and Mr. Cáceres reached the basin of the Caldá rivulet, which they found very full, and more to the westward they arrived at the banks of a still larger stream with water of a reddish colour.

The explorer Ibarreta came with boats along the upper river Pilcomayo and according to the indians passed by Caldá.

The explorer Albert Frik crossed the Paso Caldá and going in a northerly direction came to an ample stream, after three days march on foot. This agrees generally with the maps of Messrs. Asp and Astrada.

The *pilagas* cacique, Kanachi, alias Sargento Cabral, declared that he knew that countrymen of his had come from Buena Ventura along the border of a stream which flows into the Caldá channel.

The old cacique Nalchí, also *pilagas*, said that by following the Caldá stream, about two days journey up stream one can see that it approaches another large river channel more to the north, so that from each may be seen the woods on the banks of the other.

Also the indians say that the Big river, seen by the explorer Frick, does not come far from the westward, but that it issues from a great lagoon to the north and west of Caldá.

All this made me decide not to lose time in seeking and exploring the river that Mr. Frik reached, but to go on along the Caldá stream and its most important and straightest tributary, considering its channel to be the natural continuation of the Dorado river.

Oct. 18. Kms. 438 to 452.

I sent Mr. Cáceres and Mr. Casanova on a reconnaissance as far as the river Porteño, with orders to rejoin us at a place called Nalaik.

I started on the river towards the west by the Caldá channel

or "Arroyo Dorado". The indians of the cacique Nalchi assisted us over the rapids up stream from the point where it spreads into the lagoon, and we went a distance of 15 kms. We encamped at Lagarik.

The river flows between rather high banks, with little current. At night we were visited by some pilagas indians.

Oct. 19. Kms. 452 to 460.

Up stream above the Takaik pass.

We continued up stream, at first through long and deep reaches, but soon the banks became lower and we then noticed greater, incline, more current and little depth, 25 cms. in the stream.

The bed of the stream is more loamy and slippery, so that the work of dragging the boats was rendered easier.

We reached a series of shallow rapids; we crossed the first one by dragging the boats over, and I then sent for the oxen of the land convoy which was encamped at Nirazat.

Meanwhile I observed the volume of the stream and found 173 litres per second, not much more than the 138 found in the Dorado, above the junction with the Pilcomayo, which indicated with the force of numbers, that further to the north there must be more ample streams, united, or separated by the marsh and that they discharge into the lower Pilcomayo river by the waterfall Salto Palmares.

In the stream we found many fish, "raya" the sharp tail of which is very venomous, rendering it dangerous to wade without boots on. One of the men was wounded and suffered great pain - he remained hors de combat for several days.

Oct. 20. Nirazat.

I started on muleback to explore in advance. The ground generally continues to rise. We must overcome the last of the series of rapids that had detained us the day before, which is more than 2 kms. long, with a difference of level of about 1.50 ms. After this came a swamp composed of lagoons, watercourses and marshes, among which the stream we were navigating threaded its tortuous way in an insignificant channel, continuing, as reported by the indians, further than Nalaik.

Whilst we were preparing to pass the rapids above mentioned with the aid of the oxen, a big column of indians passed, accompanied by their wives and children. They were on their way to the house of our ex guide Bernardo Ríos to trade skins and feathers. These were carried by the women, two asses and one mule, whilst the

men with little gallantry, looked only after their dignity, carrying nothing but their arms.

In the afternoon having passed the rapids, after hard work both for men as well as for oxen, on account of the soft and muddy bottom, we continued our progress poling or dragging the boats in the water in search of a channel of greater depth in the swamp until night overtook us, before we had succeeded in reaching firm ground. We were therefore obliged to encamp on the muddy border of the lagoon.

The scouts, the interpreter Federico and an indian guide who had been sent ahead returned with the report that the water ceased a little way on, several branch streams and dry water courses going further towards the west. This was bad news, not at all calculated to cheer the spirits of the crews who had struggled hard all day in the water.

Oct. 21th. Nirazat Lagoon.

Cloudy, at night a little rain.

I left on foot to personally inspect the ground gone over by Federico and if possible to go further.

The marsh continues towards the east to be covered with "totora" and intersected by channels, in parts dry or with very little water. It looked as if the branch that has a trend towards the S. W. must be the principal one and probably continue in a more or less pronounced form as far as Pagarandí and Nalaik.

I think it of interest to quote the following from my diary:

« The upper Pilcomayo, united or in various branches, must
« lose itself in the marsh to the north and west of our present position
« (the Dorado brook to the north of Nirazat).

« The river which according to Frick exists about eight leagues
« to the north of Caldá appears to be the same that on the map of
« Astrada has its origin in a lagoon and which the former crossed;
« this river also disappears further down in the Patiño marsh. More
« to the northward will appear other branches which are those seen
« by Astrada and Asp; but which they have not been able to locate
« in their true position for want of rational mensuration with
« instruments. »

Further on we shall see that this supposition, as regards the upper Pilcomayo, was correct.

The day before, we had advanced one kilometre into the Nirazat swamp, and not having been able to advance further in that direction, I decided to return to the rapids above mentioned, where there is dry means of communication with the higher lands to the south,

and thence to undertake a reconnaissance of sufficient extent in order to determine our future most favourable route.

The indians of the neighbouring "tolderías" who had come to the lake Nirazat to fish, helped us and begged rum for their friendliness.

It is always sad to order a retreat, the reflection of which is immediately noticeable in the discouragement produced in the spirits of the crews, but fortunately it was not for more than one kilometre and after that, again: Onwards!

In the afternoon I left with the guide Prudencio Gomez and the interpreter Federico, on horseback, with the intention of not returning, until I had secured more certain and trustworthy data which would direct us in search of the upper river Pilcomayo.

At a place called Mapzat, we passed a "toldería" in course of construction, where the indians received us well and provided us with a guide, who mounted on a beautiful black mare was to lead us to the "toldería" of the cacique Sargento Cabral, alias Kanachí.

As regards the riding gear of the indian horseman, it is worthy of note that it is of the simplest: a bridle with cord bit, a pad instead of a saddle, with girth and no stirrups; they saddle and mount from the right side.

In this "toldería" we noticed several half breed indians,—not good looking.

The indian guide placed himself at the head of our little column and we went as far as Pagarandí, where we passed the night under the same tree as the governor Luna Olmos the year before.

The country is fine and pastured, with groups of algaroba and a few palms; we crossed a dry water course several times.

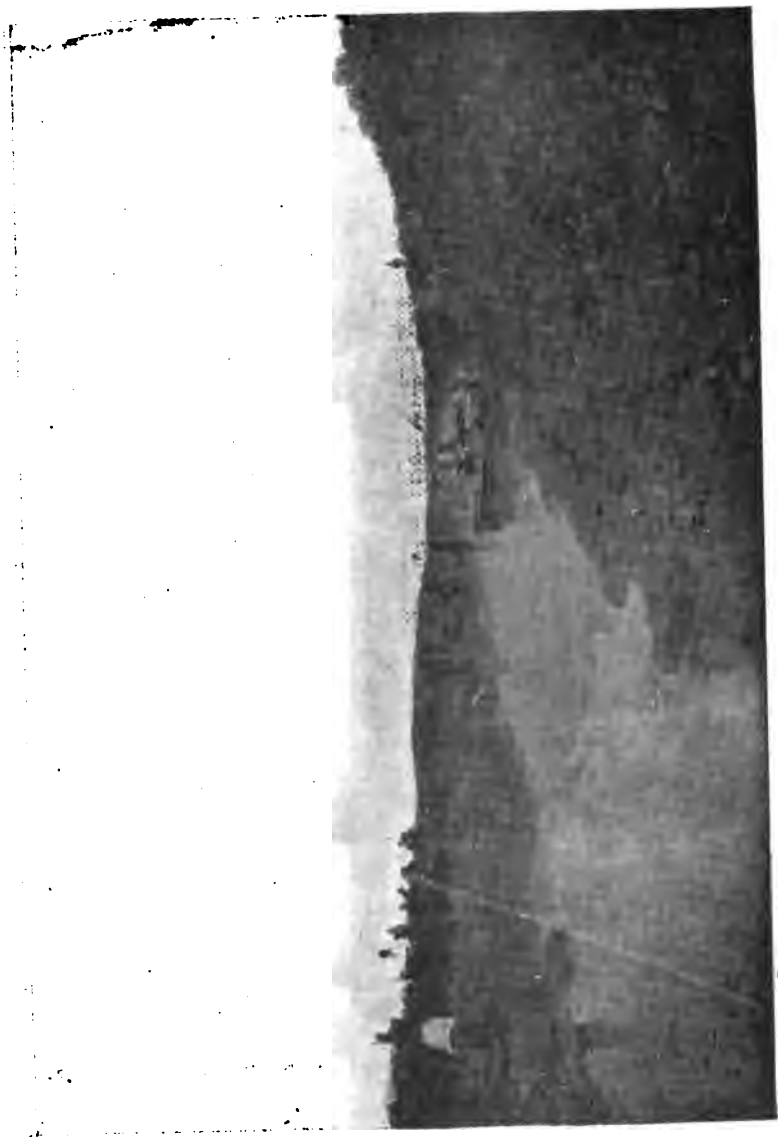
Oct. 22th. Pagarandí.

Cloudy, later on heavy rain.

We started early in the direction of Nalaik, where I had the good fortune to discover, before the rain began, the camp of Cáceres and Casanova who had returned from the river Porteño and had set up their tent on the bank of the Dorado, in a big bend of this stream.

They had made a successful excursion without mishaps, but discovered only a small extent of true quebracho woods.

Soon after my arrival appeared several Pilagas indians with the report that the Sotegais "bad indians" who inhabit to the north of the river Pilcomayo had assaulted the "toldería" of the cacique Sargento Cabral (Kanachi) that same day in the early morning and carried off women, children, horses and sheep. Also it was believed



Arroyo Dorado or Tola. — Nivazat.



Arroyo Dorado or Tula, Viracat.—Column of Indians on the march

that another Pilagas "toldería" more to the north, on the other side of the Dorado stream, had been attacked at the same time. At first we did not give much credit to these tales of the indians, but more of these came along, all with the same accounts. Having gone a little way from his tent, Mr. Cáceres surprised two Sotegais indians who were hidden on the edge of a wood near by watching us, and who fled at his appearance.

After breakfast I started in company with Cáceres, Gomez, Federico and the indian guide, well armed, to visit the big river which the indians were unanimous in locating towards the north near our quarters.

The guide led us in nearly a westerly direction, passing between the Dorado brook and the Nalaik marsh and lagoon, and then veering towards the north we crossed the Dorado which here as at Mr. Cáceres' camp runs in a very deep bed, with high bluffs of old formation, at the foot of which we noticed sand banks of a yellow colour of which also the water partook.

At the other side of the Dorado we came across an abandoned indian "toldería", which we afterwards knew was the second one that had been attacked; the only living being in it was a pup which howled dismally in its solitude. The cacique who had hidden himself in the woods came out in a timid way and said that the Sotegais had carried his mother-in-law off captive, and that as soon as he and the friendly caciques could muster their forces, they would go in search of her, attacking and pursuing the bad indians. This good son-in-law did not seem to be in a great hurry.

We then crossed toward the E. N. E. over open pastured fields turning along the bend of a channel or long lagoon, and skirting the same we found that gradually it widened to nearly 30 metres. We followed in the direction of the line of high thick woods that indicated the course of some river, and hurrying on we reached the point where the channel above mentioned, and which the indians call "Soret Satandi", joins a wide and ample river, somewhat swollen, waters turbid and reddish with high exterior banks, and lower lands formed by the bends of the river. There could be no doubt that we were on the banks of the upper Pilcomayo; it may be easily imagined with what satisfaction we gazed on its ruddy waters, which here run rapidly over the submerged bank at the point where the Soret Satandi discharges into it.

To this point then it was necessary to bring the boats, cost what it might, overcoming in any possible manner the difficulties to be met with along the 60 kms. which separated us from Nirazat, the most advanced point up to the present, of our navigation.

The colouring matter in suspense settles lower down and forms the red soil so common especially up stream from the big marsh to the east of Caldá.

The bed of this part of the upper Pilcomayo appears to be of more recent formation than that of the Dorado, which presents a section very large in proportion to its insignificant body of water; and the somewhat confused tradition of the indians also favours the supposition that at a former time the river Pilcomayo flowed in the bed of the present brook Dorado and that this branch was blocked more to the west, the river Pilcomayo opening a new channel which we now contemplated, the Dorado remaining with the little water that it may receive from the local lagoons and marshes.

We returned by a shorter road, crossing the Dorado by a ford near our quarters, understanding that the astute indian guide had led us a long way round in order to find out all about the attack made by the Sotegais.

At night Sargento Cabral came and told us very calmly that the assailants had killed his brother, showing little eagerness to prepare for the pursuit and punishment of the enemy.

Speaking of the river Pilcomayo he said that he had not heard that this river reached as far as the Salto Palmares and did not know if or where its waters disappeared.

Oct. 23th. Nalaik.

Cloudy, cool, later heavy rain.

We returned towards Nirazat, studying the Dorado brook, having been able to reach its border three times between Nalaik and Pagarandí on firm land between the wooded hillocks. Here the Dorado presents the same aspect as in Nalaik with banks as high as 8 ms., unequal channel and with varying current and depth. Then crossing the marshes on foot we approached the brook at Pagarandí, finding high banks and reaches which appeared deep with very little current.

We turned towards the south looking out for firm footing as far as Mapzat where we crossed over again on foot as far as the river, perceiving on the high ridge on the southern bank a circular indian "tolder'a" protected by a strong palissade against the most dreaded enemy of the indians, the man-eater tiger. The river here presents another aspect, with lower and less abrupt banks, shallower and with less water, scarcely sufficient for the boats. We noticed banks of red sand brought down by freshets.

Again we had to retrace our steps in order to reach the river more to the eastward, somewhat further up stream from the Nirazat lagoon and marsh.

Once again we had to leave the animals and go through the mud to reach the channels and small dry water courses, which in times of flood form the communication between the upper Dorado river and its continuation lower down, below the above mentioned Nirazat marsh.

I went along these water courses on foot towards the S. E. where they approach a dry point with palm trees which extend towards the north from the solid land, a little to the westward of our camp in Nirazat. I climbed a palm by means of climbing hooks and saw the great marsh spread out to west, north and east. At a distance of about 2 to 3 leagues to the north a line of forest extends from west to east, and along or on the further side of this forest should flow the water of the big river we discovered, which, lower down, probably is scattered in numerous branches in the extensive marshes, to be reunited in the formation of the rivers to the eastward of the Patiño marsh, among them being, the northern and southern branches of the lower Pilcomayo.

All morning it rained heavily and we arrived at our camp at Nirazat, drenched and hungry.

During my absence Meyer, Ayala and young Cáceres had moved our equipment and provisions to a point on the cart road, the boats being left in the Dorado brook.

I decided to have the boats hauled by oxen to the groups of palms above mentioned and after that employ part of the gang of men to go over the marsh, taking provisions for a few days. Meanwhile Mr. Cáceres should transport all our effects in carts and on mule-back by land to Mapzat, the first point chosen for rendezvous.

Oct. 24th.—Kms. 462 to 468.—Nirazat.

Fine weather, very hot.

We succeeded in transporting the boats and provisions for 8 days, as far as the last channels of the upper Dorado, making use of the oxen as far as possible; it was a hard days work, having to drag the four boats across the almost dry marsh over the "totora" and mud. I continued the telemetric measurements.

Oct. 25th. Kms. 468. *Zanjón Dorado* up stream from Nirazat.

Rather cloudy.

Working hard we pushed the boats forward through the scanty water in the channels, succeeding in making 660 metres during half the day.

We employed the afternoon in forming a dyke across the bed in order to deepen the water, having noted that gradually the

channel became more regular, with better defined sloping banks and sandy shores. On both sides there were extensive "totorales".

Oct. 26th. Kms. 468 to 472. Zanjón Dorado.

Cloudy night. Swarms of mosquitoes.

The water in the channel rose 15 centimetres on account of the dyke.

Four hundred metres further on the effect of this rise of 15 cms. was no longer noticeable, but fortunately after struggling over 500 metres more we came to reaches of greater depth, which afterwards divided into several branches, thus again obstructing our progress.

The foreman Stei came with oxen to assist us, but these proved of little use, as they sunk to the belly in the loamy earth deposited over the hard impermeable "tosca".

There was an abundance of "chilca", "sauce" and "alisos" on the banks.

By mid-day we reached the rendezvous, down stream from Mapzat, about 500 metres from the cart road.

In the afternoon we explored the stream as far as Mapzat, finding a little more water.

The day previous, the man Spindola had seen two tigers: they abound, but our very noisy men from Corrientes and Paraguay drove away all the wild animals. There are few birds in these swamps and one seldom hears the cry of water fowl.

At night an old Pilagas cacique came along with 20 indians and visited us on his way westward to aid Sargento Cabral in the projected attack on the Sotegais. We made use of these indians getting them to drag the boats, after having offered them good pay in tobacco, cloth and knickknacks.

Oct. 27th. Kms. 472 to 482. Zanjón Dorado.

Cloudy.

We continued our navigation in shallow water assisted by the Pilagas, who after having carefully deposited their scanty clothing ornaments and arms in the boats, followed on foot along the bank, getting into the stream to help whenever the scarcity of water hampered our progress.

The indians carried war arrows with large iron points and a few had lances.

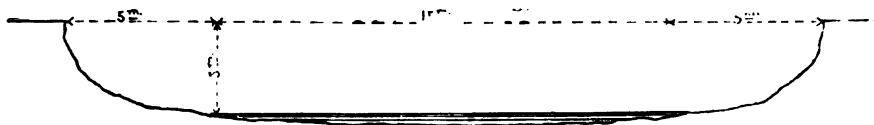
As a curious fact may be noted, that among them there were three who could not eat anything cooked in a pot because their wives were pregnant.

The river splits up into many branches, and we followed always the one indicated by the indians, who could have led us anywhere

in this Mesopotamia of rivers and low islands covered with willows, where it was very difficult to find one's way.

We passed Mapzat which we had visited in our exploration by land and saw many indigenous weirs very well constructed of "aliso" stems, picked perfectly straight. Generally they were funnel shaped, with the larger opening pointing up stream and at the other end a platform on stakes driven into the bottom of the river. The indian, seated comfortably on the platform, awaits the arrival of the fishes through the funnel and then catches them with a net, or harpoons them with an arrow pointed with a piece of thick wire. On the platform they also have a small fire, which serves to attract the fishes and to cook them at once.

The section of the river becomes gradually better defined, with higher banks having abrupt sides, generally like the following section.



There are many willow trees embedded in the river.

Oct. 28. Arroyo Dorado. Kms. 482 to 488.

Somewhat cloudy.

The river becomes rather better for navigating; with regular longer reaches, separated by short spaces of "tosca" bottom of greater incline and current.

The banks rise gradually up to 5 or 6 metres forming an important valley channel.

Oct. 29. Arroyo Dorado. Kms. 488 to 502.

Rained during the night, still cloudy.

The river makes a big turn to the north of the lagoon and district called Pagarandí.

At noon three men and some indians who had been sent by Mr. Cáceres, arrived to help us to drag the boats; he had gone ahead with the land convoy, as far as Nalaik and had encamped exactly where I had found him some days before, in company with Mr. Casanova.

There are a great many fishes, of which the indians who accompanied us caught many by throwing their long wire pointed arrows, or using them as harpoons. To kill them they bite them with their white teeth on the head and the scales sticking to the

coffee coloured skin of their naked bodies become strange ornaments, shining in the strong light of the tropical sun.

At night our interpreter Federico sang a characteristic song without any words, and after him the indians lying round the fire rose in turn one by one and repeated, each, after his own style the same savage song, trying to excel his companions in special variations and modulations. Excited by their songs they required but little pressing to go through their national dance. They formed a circle and pressing against one another they leaped to the compass of a very simple melody with the incoherent words "a, ya, ya, y ay, y ay, y ay".

Oct. 30th. Arroyo Dorado. Kms. 502 to 511.

Rain during the night, still raining.

The indians suffered a good deal from exposure to the weather, having very little to cover themselves with, as a rule only a small piece of cotton cloth; they slept round the bivouac fire huddled together.

We had a hard day's work and arrived late at the Nalaik encampment. The indians had got tired and abandoned us, going ahead to the encampment, leaving us therefore reduced to our own resources.

Oct. 31th.. Arroyo Dorado. Kms. 511 to 513.

The land convoy went on following the course of the river as much as possible and taking all the provisions etc. that could be carried in one trip by the cart and pack mules; the rest of the baggage and provisions was put into the boats.

Several Pilagas caciques came to see us, beg presents or work, as might turn out. An ugly, tall half-breed did us much harm by asking as payment for dragging the boats, shirts for himself and people, especially at this article had become scarce for our own party; but at last after much palavar we managed to start in the afternoon with a good number of bronzed assistants. We made little progress on account of want of water. After having begun the construction of a dyke, we took up our quarters on a sand bank which during the night became a source of great annoyance because of the high wind that arose. We suffered much from the innumerable mosquitoes.

In the afternoon the cacique Kanachi (Sargento Cabral), friend of Governor Luna Olmos and of Mr. Cáceres, made a speech to the other caciques and their followers, exhorting them to assist the christians, who he said, were friends of the people of the country and would pay them well for their services. It was interesting to see the tall thin cacique, with a certain dignity, deliver his harangue

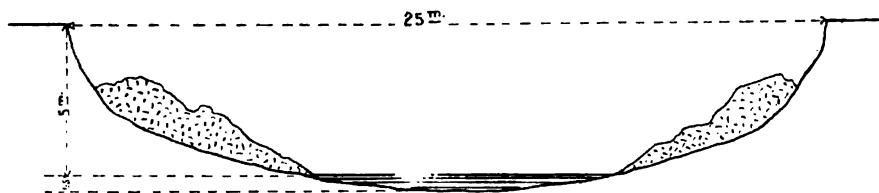


Arroyo Dorado or Tala -- Pugarandi.

to his countrymen. It seemed however that it did not produce any great effect, inasmuch as the indians seemed to incline more to the half-breed, already mentioned, who was working against us.

Nov. 1st. Arroyo Dorado. Kms. 513 to 522.

We continued struggling with the river Dorado, which keeps on the same, with abrupt banks of 5 to 6 metres high, partially fallen down, the normal section being as shown in the following illustration.



At noon we made another earthen dyke to raise the water, but with very little result on account of the relatively steep incline up stream.

The telemetric survey proceeded with great delay and tediousness because of the many turns and the unequal length of the small reaches, so that there were sight ranges of only 50 metres.

At 5.30 p.m. being in front of the Soret Satandi channel after having overcome a long portion of the river, with shallows and very little water, I decided to consider as finished the navigation of the Dorado, and to try to pass the boats over the high, dry land as far as said channel, which would form an easy mode of communication with the channel of the upper Pilcomayo.

We encamped, selecting a spot offering facilities for raising the boats onto the bluff and started to discover the best route for the land carriage, accompanied by the cacique Kanachi, who again repeated the belief of the indians, of which we had already heard, that the Dorado higher up again approaches the Pilcomayo; that originally, many years ago, the Pilcomayo flowed through the channel of the Dorado, which formed its principal branch, the present river being the less important branch; that in a great freshet it was obstructed by an accumulation of earth, trunks and branches of trees which it brought down the Dorado branch, and that then the river deepened and increased its present channel.

We had intended to go up the Dorado as far as the obstruction referred to, but the little faith we had in the tales of the indians in general and the obstacles which the river presented to navigation, decided us to cross over to Soret Satandi. Further on it will be

seen how in vain we tried to come across the interesting obstruction referred to.

Nov. 2nd. Arroyo Dorado. Kms. 522. Nalaik.

Day cloudy and cool.

I calculated the flow of the Dorado at this, the terminal point of our navigation and found 232 litres per second, rather more therefore than the stream found in the rapids at Nirazat (173 litres per second), the explanation of this being, that the Nalaik is a united stream, whereas the measurement in the Nirazat was taken somewhat below the lagoon and marsh of the same name, where the waters were somewhat scattered over an extended surface.

I then made the map of the route as far as Soret Satandi stream, determining by observations of level the vertical section of both water courses and of the ground separating them.

See the section shown on the annexed map. Sheet N° IV.

This shows a distance between the two shores of 2785 metres, over open fields with wooded knolls, crossing longitudinal depressions, between the banks of the Dorado and those of the channel mentioned and of the Pilcomayo.

Meanwhile the boats and equipment were transported to the point nearest to Soret Satandi, facing the Paso Lata in the Dorado stream, where Mr. Casanova had arrived with his cart and pack mules. With the assistance of the indians and making use of the oxen and mules of the land convoy, we transported all the baggage to our camp on the borders of the channel, and launched the boats, there being at this point more than a metre depth of water.

At night there was a great distribution of tobacco and knick-knacks to the indians who had worked for us, each cacique forming his people in a large semicircle in front of the tents, with the women and children behind the group of men. They were greatly pleased with the handkerchiefs and lengths of gaudy patterned prints and with the looking-glasses, combs, hooks and rosaries, these last the women at once put round their necks. The cacique Kanachi received also powder, shot and percussion caps. The half-breed cacique who did not want to work, also came with his following and was told off to a position in the third rank, from which they sadly contemplated the rewards accorded to the virtuous; but that they should not be disheartened, to each one was given a rosary and a fishing hook.

I observed the latitude of our camp on the borders of the Soret Satandi channel (24°, 9' 58" S).

Nov. 3rd. Kms. 327. Soret Satandi channel.

We started navigating again along the Soret Satandi channel

in still waters, broad and deep and two hours afterwards landed on the southern bank of the upper Pilcomayo, at the junction of both streams.

The water of the Pilcomayo had for us, who had been accustomed to drink so much brackish water, a positively sweet taste, almost insipid; it is very turbid and of a reddish tint.

I made arrangements for the journey of Mr. Casanova to Buena Ventura with draught and saddle animals and those for food, and ordered the preparation of a two months supply of jerked beef for the river convoy.

There came an indian, called Santiago from Buena Ventura, who speaks a little Spanish and is employed to recruit indian labourers for the sugar estates in Salta. As he knew all about the roads we engaged him for the land convoy.

Mr. Casanova received the following instructions:

« Proceed with everything belonging to the land convoy to the
« Colony Buena Ventura, opening a way for the cart wherever
« necessary, draw a sketch plan of the route followed, with bearings
« on known points having proper names, and await in Buena Ventura
« the arrival of the river division.

« As it might turn out that at Cochotero or Tronquitos the
« cart road goes near the Pilcomayo it might perhaps be possible
« to communicate with said division. »

In the evening I measured the section of the Pilcomayo, upstream from the junction with the Soret Satandi and determined the volume of flow, finding this, 40 cubic metres per second, the height of the river being probably about 1.50 ms. above mean low water. The maximum depth of water in the section was 3.50 ms., at the point right in front of the outfall of the Soret Satandi 3 ms., and in the latter about 50 ms from the mouth, 2.6 ms.

The river Pilcomayo was therefore full; the current had a velocity of 1.5 ms. per second and bore a considerable quantity of water (40 cubic metres per second).

It is worthy of mention that one of our messengers who had been sent to the depot at the junction of the Pilcomayo and the Dorado, returned with the news that the Pilcomayo was falling there.

It requires naturally a long time for a freshet in the upper Pilcomayo to affect the rivers and brooks that drain the Patiño marsh, and only by means of daily records of water gauges placed above and below the marsh, will it be possible to ascertain this interval.

Nov. 4. Pilcomayo river. Kms. 527. S Lat. 24°-8'-40".

Along with Mr. Cáceres we made a reconnaissance by boat of

the Pilcomayo down stream. We quickly noticed that the banks became lower as also the height of the trees. These continued to be very varied: "jacarandá", "palo santo", "algarrobo", some quebracho, and abundance of willows. The river, which at the junction with the Soret Satandi runs rapidly, becomes quieter in fine long, straight reaches, and only acquires greater velocity where it begins to branch out and scatter, about nine kms. from said junction, and where the banks disappear and the water washes the roots of the "totora". The river discharges through several branches into a great lagoon which we named the "Colorada" lagoon on account of the reddish tint of the water. This communicates through a short arm with another lagoon which we named lagoon "Chajá" on account of the astounding number of aquatic birds "chajá" which swarmed on the shores and islets.

Towards the east and south there are great marshes, and it is probable that these, along with the lagoons which we had studied, form the great lagoon "Escalante", marked on the map of the explorer Asp near the intersection of parallel 24° with the meridian 2° W of Buenos Aires (60-22'-W of Greenwich).

We crossed the two lagoons, noting a maximum depth of 1 metre and then coasted round, close to the shore, without discovering any outlet of any importance, but everywhere found low shores covered with "totora", only broken by narrow channels or coves which at a short distance became merged into the marsh. This marsh, as stated already, is like an enormous sponge, receiving the large volume of water, which subsequently scatters over a great extent of territory to emerge drop by drop through the sources of the rivers and brooks, on its eastern confines.

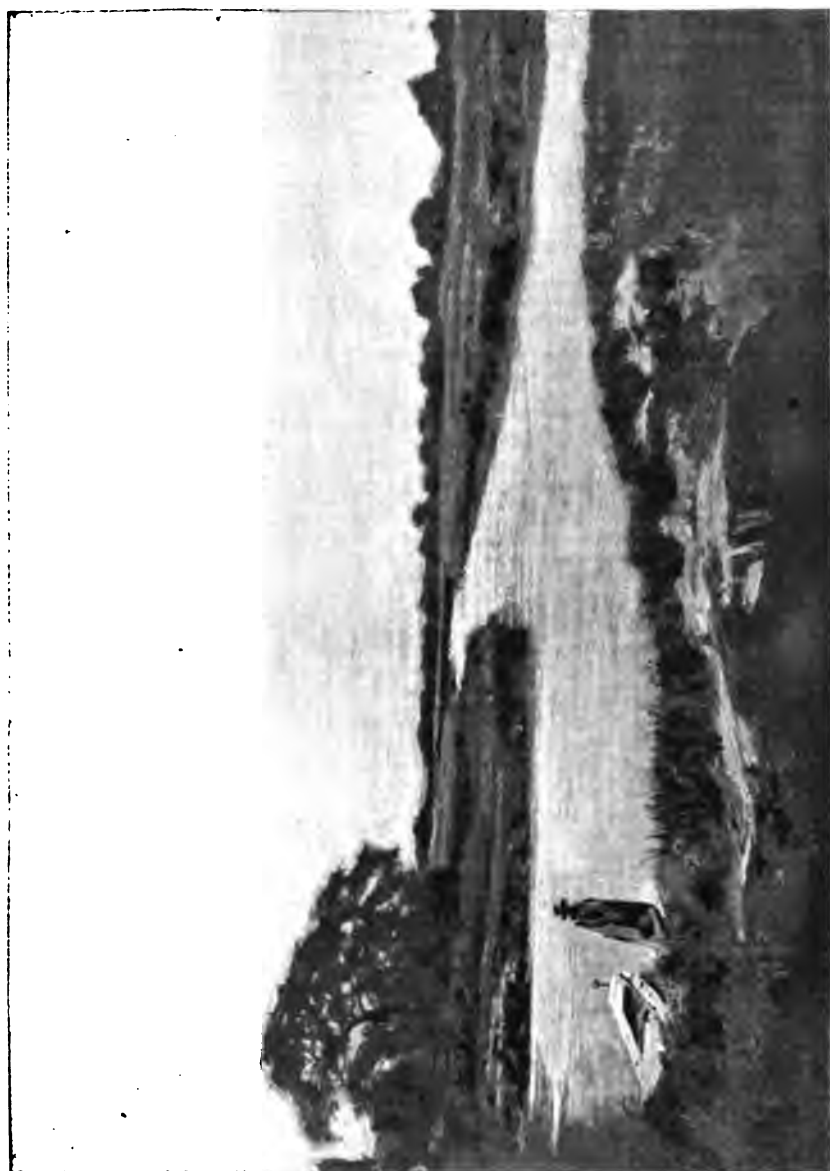
Everywhere we found the water turbid, excepting in the N.E. corner of the Chaja lagoon, where it was clear and bluish, probably brought from that direction by an affluent which, not being swollen, had its water clear and settled.

In the afternoon we returned to the junction of the Soret Satandi.

Nov. 5th. Upper Pilcomayo river — Kms. 527 to 533.

Since Nov. 3rd. the river had risen 6 centimetres.

I arranged with the cacique Kanachi that he should show us the spot where the bifurcation of the channels of the Pilcomayo and Dorado had existed, and sent him along with our interpreter Federico, ordering them to join the land convoy and lead it to the place sought for, there to await, with all the animals, the arrival of the river division, so that afterwards we might make a suitable exploration

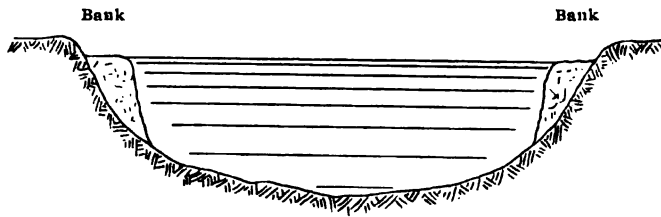


Upper river Pilcomayo. Junction Soret Satandi

of that interesting locality. In the event of his finding the place, he was promised as a recompense the mare of the troop, the most valued present that can be made to an indian.

Our store of jerked beef being now dry, in the afternoon we embarked to navigate the river Pilcomayo up stream.

We had to overcome a series of rapids in the first two kilometres of the journey; subsequently the incline became less and the course presented stretches with stronger current and lower banks, the stream nearly filling the section of the channel, where the river had formed new banks of slime on both sides.



To the north and south there are extensive fields, open and swampy, the forest on the banks is low and without trees of valuable wood.

Nov. 6th. Km. 533 to 545.

As we ascended the river we noticed that it was fuller, reaching the top of the banks and in some places overflowing the ridges and inundating the adjacent lands.

It does not appear impossible that what the indians say may be true, — that the present course of the Pilcomayo dates from a comparatively recent time, — judging by the area of its section, which in several parts is less than that of the Dorado.

We sought in vain for a dry place on which to camp, and had to pass the night in the boats made fast to trees on the banks which were quite wet and muddy.

Nov. 7th. Kms. 545 to 561.

The river continues swollen, filling the channel to the brim. Lower down and somewhat above the junction Soret Satandi there must exist a change of incline which causes the rapids and, imparting greater velocity to the current, prevents the waters from completely filling the channel, as it does here above.

We passed many indian "tolderías" on the ridges, abandoned on account of the flood. It is a strange sight to see the river on the point of overflowing, running at a greater elevation than the adjacent lands.

At night the river was sufficiently low to allow of our

cooking on shore, though it was still preferable to sleep on board inconvenienced by packages and cases.

Swampy land

Swampy land



Nov. 8th. Kms. 561 to 572.

Great number of "alisos" brought down by the current indicate extensive growths of the same higher up stream.

The flood had deposited slime all along the lower portion of the banks to a height of 1 metre, and it was interesting to observe how, as soon as the ebb set in, the water from the inundated lands made its way through cracks caused by the sun in the mass of slime, gradually widening them, and so reestablishing the normal drainage of the low lands into the river.

In many parts we noticed trees embedded in the banks; these being vestiges of forests of former times.

The "Chañares" were full of fruit, to the great delight of the men, who ate themselves sick.

Nov. 9th. Kms 572 to 585.

Near kilometre 578 the river receives a small affluent from the north and further on two other insignificant ones from the south. After this there appears to be a change of incline in the land from east to west, manifested by a well pronounced rapid, and a sudden change becomes observable in the nature of the woods; the hard wood trees in a line from north to south ceasing as if they had been cut down, being substituted firstly, by open ground and then by willows and especially "alisaes" of better development, towards the west.

Above the rapids the banks are lower, and consequently the land more swampy.

It occurred to me that at this point in times of great freshets the water might overflow towards the south and make its way to the Dorado river. It would have been interesting to make a thorough study of this, but there was no time for it, and as we had no news from Mr. Casanova and the cacique Kanachi, I decided to go forward without delay.

Meanwhile it appears that we have passed the crest of the flood on our way up the river, which continuing to fall, presents from km. 580 the aspect of a stream in normal condition, with high steep banks already dry above, and below crumbled down and wet. In the widest portions of the river there are banks and

flat shores, and a deeper bed, with increased current, winding from shore to shore.

Nov. 10th. Kms. 585 to 599.

The borders of the rivers were still very swampy, this showing that it had only recently begun to fall.

A strange appearance was presented where the banks, worn away by the flood, exposed the roots of the straight "alisos" which had penetrated into the ground in a plumb line, as in direct continuation of the trunk. Gradually the "alisos" became scarcer, the willows predominating. There is abundance of "caña de castilla" and "cola de caballo" on the banks. Lat. in km. 598.7: 23° - 58' - 12" S.

Nov. 11. Kms. 599 to 614.

Cloudy.

At km. 601 abreast of the lagoon Nogot Pocoibi we found a board in form of a raft, bearing a letter from Mr. Casanova with the news that the cacique Kanachi with all his people had abandoned him and gone away, stealing the mare that had been promised him as a reward, without having found the bifurcation Pilcomayo Dorado. A little further on we espied a little white flag on a high willow and found another letter from Casanova, telling us that the Karay indians had informed him that we had already passed that spot and also that the guide Santiago had left him. Casanova had continued his journey that same morning.

Owing to the conduct of Kanachi we lost all hope of proving the existence of the oft mentioned bifurcation, which we greatly regretted, as also that we had not time to spare for the pursuit and punishment of the thieving cacique.

The river continues without marked variation, of a very uniform appearance, with a few small rapids in the narrower parts and in other wider parts, with still pools and shallows. The banks rise gradually, the height of the dry portion, not reached by the last flood, increasing.

Nov. 12th. Kms. 614 to 625.

Rain.

The terraces left by the last flood at the foot of the banks proved very useful for the men towing, as their task was very hard owing to soft muddy foothold.

Nov. 13th. Kms. 625 to 637.

Cloudy and relatively cool.

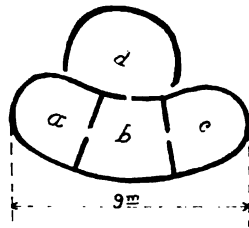
We found that taken all through November was not so hot as October.

At night we heard singing in an indian camp near by, but no inquisitive indians came near us.

So far we have noticed but few wild birds on the shores of the upper Pilcomayo, as also few fishes in its turbid waters.

At last about noon I had an opportunity of seeing the famous indians Sotegais. (this means, bad, in the language of the Pilagas indians) or Chorotis, as they are called more to the westward. They awaited us on the river bank, without weapons, as a sign of their friendly intention, and offered to tow the boats, having no doubt heard that we paid well for such service. In appearance they are inferior to the Pilagas indians, being thin, bony and dirty, with their ornaments more disorderly, excepting the broad cow hide belt decorated with a long pendant fringe. They speak a language quite different from that of the Pilagas. As a rule it is rare that these indians of different tribes can understand one another.

Further on we came to a large "toldería", recently evacuated, the indians having withdrawn their women, children and domestic animals, probably on account of our approach. We saw a young brownskin making off, and visited the abandoned camp which consisted of several large dwellings, strongly constructed, more or less as shown in the following illustration.



There are three roofed apartments *a*, *b* and *c* and an open yard *d*; all the doors can be secured by means of thick bars, probably as a protection against tigers, which as already stated the indians greatly dread.

In the river we had noticed stakes driven at regular intervals into the ground at the water's edge, the object of which I could not ascertain, but suppose it was to indicate the fishing ground of each family.

On both sides of the river there are tracts of lower land, there being noticeable on the Argentine side a longitudinal depression parallel to the course of the river, which in the deeper portions formed extensive lagoons and marshes. This depression must receive water from extensive tracts to the south and west, the level of the

water in its lagoons being maintained much higher than that of the river in its normal condition (1.3 ms. over the rather swollen river as we observed it).

It is not impossible that this depression, with its string of lagoons and channels continues as far as the lagoon Soret Satandi, and further down, through the channel of that name, has communication with the river Pilcomayo.

During the night we were surprized by rain, with the resulting confusion.

Nov. 14. Kms. 637.

Day broke with rain, which continued all day.

The contrast of the cool rainy weather with the heat of the preceding days was very marked. We were actually shivering with cold in the Chaco in the month of November!

Nov. 15. Kms. 637 to 641.

Cloudy with drizzle.

Some 700 metres up river I found another message from Casanova, indicated by a flag on a tall pole, in which he announced that he was encamped to the north of the lagoon Grande Final, having unsuccessfully tried to find a way for the cart.

I decided to see him; so after a walk of three to four kilometres on foot over wet tall grass we reached his camp. He was of opinion that the cacique Kanachi and the guide Santiago had deliberately deceived him, having recourse to a stratagem, making use of him as a protection against the Sotegais in order to cover the march of a column of indians with their wives and children, whom Santiago had engaged for work on the sugar plantations in Jujuy. As soon as this column had passed the region where the road approaches nearest to the Pilcomayo and is exposed to the raids of the Sotegais, they both broke their engagements, the cacique besides, carrying off the mare which he had been promised if he showed the bifurcation of the Dorado.

I impressed on Mr. Casanova the great interest and advantage there was in being able to take the cart to Buena Ventura, and so proving practically the possibility of opening a highway along all the border of the Pilcomayo. Nevertheless, on returning to the boats my impression was that we would not have the pleasure of seeing all the land convoy in Buena Ventura.

Mr. Casanova ought to have gone south and west from the lagoon Pico Blanco, to flank the woody region, which is poorly supplied with water, of which mention is made by Governor Luna Olmos, as extending to the south and west of the lagoon Grande Final.

During the three days of drizzle and rain, with a temperature of 12° to 15° cent., exceptionally low for this region at this time of the year, we noticed that the wild animals felt the cold; the ducks did not care to fly and the little swallow chicks were so numbed by the cold that they allowed themselves to be caught in the hand.

Raining all day.

Nov. 16. Kms. 641 to 650.

The river continues with well defined section and high banks (4 ms. over surface of water). In general the upper Pilcomayo shows a channel of greater dimensions than that of the lower portion, which is quite natural in a river which does not receive affluents.

We passed a big camp of Sotegais indians; the men came down to the water's edge, without weapons and behaved perfectly well, even helping to tow the boats.

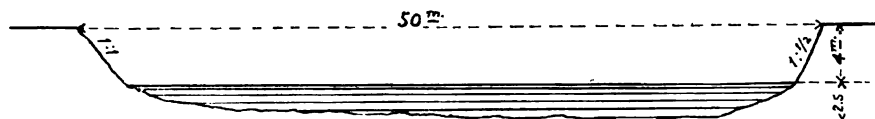
The Sotegais are not such beggars as the Pilagas; they give everything for tobacco. They visited us in our camp and showed much pleasure in listening to the music, in which respect they compared favourably with the Pilagas who said that the music of the gramophone was very pretty but of no use as food. These Sotegais men are strong, well developed and active; they must be formidable on the warpath.

Nov. 17th. Kms. 650 to 662.

The river preserves great uniformity as regards breadth of channel, height and nature of its banks, depth and current.

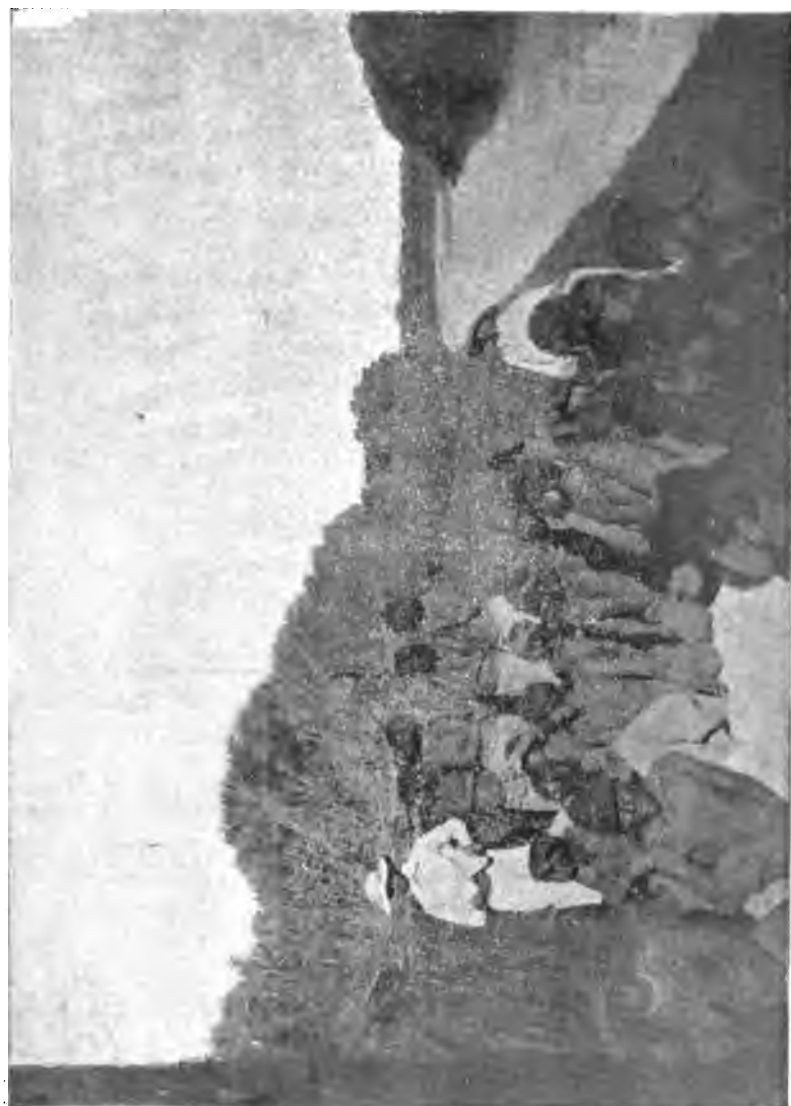
The dead tree trunks standing upright in the river bed show that the course at another time had been different from the present one.

The typical section at this part is as shown:



Nov. 18th. Kms. 662 to 675.

We came near another big camp of Sotegais indians on the northern bank of the river. They expected us, and we gave them tobacco, rosaries and small looking glasses. We then visited the camp, where the men were occupied in drinking *aloja* (a fermented drink) made from the algaroba bean, which was now mature. They invited us to sit and take part in the orgy and the women offered us crushed algaroba beans.



Upper river Pilcomayo. - Kilometre 471. Sotegais indians.

The land on both sides of the river is flooded in times of great freshets, becoming lagoons up to the base of the tall forests which can be seen at a distance of a league and a half from the river.

After the three days of rain (14th, 15th and 16th November), the weather became fresh and pleasant at night, with relatively few mosquitoes.

Nov. 19th. Kms. 675 to 690.

It would seem that the longitudinal depressions alongside the river must continue, with lagoons and marshes, to judge from the number of "chajas" and ducks we have seen in the last few days.

The river continues also to be very muddy. An experiment to ascertain the proportion of solid matter in suspension, gave 3.2% in weight which is equal to 1.8% of volume, a very high degree of turbidity, which very certainly would form a serious hindrance to steam navigation.

Nov. 20th. Kms. 690 to 708.

Observed latitude and azimuth: kms. 708 (23°, 28', 49" S).

Nov. 21st. Kms. 708 to 725.

In the afternoon we met Tobas indians, who live to the south of the river. They use more clothing and are smarter, having been more in contact with the christians, but consequently are more corrupt and greater beggars than the perhaps less civilized but more congenial Sotegais.

Nov. 22nd. 725 to 744.

Cloudy.

The river continues more or less the same, a gradual augmentation in section and height of banks being noticeable; it seems as if here it less frequently overflows onto the adjacent lands.

There are many Tobas indians living on the banks; they are fond of bright colours for dress and produce a good effect in the landscape with their feathers and red shirts.

The Tobas equally with the Pilagas are afraid of the Sotegais, or Chorotis, as they are called at this height up the river, notwithstanding that these seem poorer and not so well fed.

It may be that it is privations and hunger that give courage to the Sotegais (or bad ones) for their frequent raids to the southward of the Pilcomayo river.

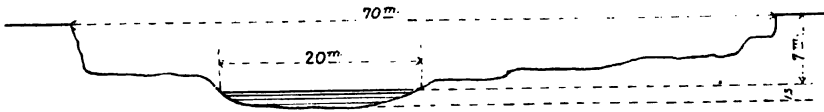
We engaged 10 Tobas to assist us in towing the boats, but only for a short time as turned out -- in the first "toldería" some of them yielded to the temptation of remaining to drink "aloja" and the rest left from fear of the Sotegais and of the Maticos, whose

territory on the southern bank of the river we were approaching.

The Tobas all carry many long wire pointed arrows, this being a sign of the existence of fresh water lakes and abundance of fish, in the vicinity of the course of the river.

With regard to the land there is little variation; below, the *tosca* more or less hard of dark red colour, and above this the layer of soil of grey colour.

We have not noticed any sand or gravel yet.



Nov. 23rd. Kms. 744 to 760.

Cloudy in the afternoon, with very strong wind from the S. E. of which we took advantage by setting sail with pieces of canvass and sheets.

It cost us much labour to ascend a series of rapids from kms. 752.5, up stream for about 700 metres. Of the crew of Mr. Mayer's boat the cook Nicolas and Nicosi, one of the men, were nearly drowned from having fallen into deep holes worn in the *tosca* by the water, whilst attempting to cross the river fastened to the tow line.

Nov. 24th. Kms. 760 to 781.

Cloudy.

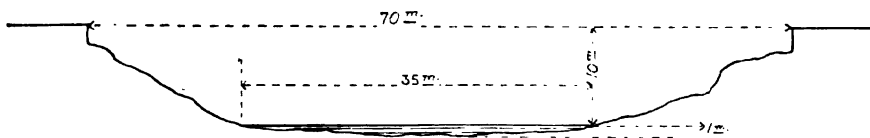
River without many sharp turns.

The country begins to assume the characteristics of the arid provinces of the north; forests not so thickly wooded, trees with sparser foliage, and fewer creepers.

We noticed the "mistol" and other trees peculiar to the arid zone. The algarrobas are very large.

In fact the river enlarges its channel in the direction up stream—not only as regards the dimensions of its section but also as to the extended erosive action of its floods.

Today we reached the record in our daily progress: 21 1/2 kms.



Nov. 25. Kms. 781 to 801.

At midday we passed a "toldería" of Matacos indians, mortal

enemies of the Tobas, — they adorn themselves less than do these so far as clothing is concerned, but paint themselves more, some of them blackening their faces completely and others put small black spots under the eyes. It is a custom among the indians that when one falls in love, he paints his face completely and if the object of his affections reciprocates, she also paints her face in a similar manner. These indians won't work except for pay in shirts, an article that has become very scarce with us.

Between the respective territories of the Tobas and Matacos to the south of the Pilcomayo, a neutral zone about 5 leagues broad has been agreed on and this is left uninhabited.

At night I took the latitude at kms. 801.2 (23° - 5' - 53" S).

Nov. 26th. Kms. 801 to 814.

The diminution in the velocity of the current which we noticed when going up the river is due rather to its tendency to fall than to any diminution in the incline, which latter does not appear to change much.

We found ourselves in the domain of the Mataco cacique Tronquito, who paid us a visit but would not work at towing the boats because he did not want to miss the feast of the "aloja". There must be many indians in these parts; they came to the river bank in groups to see us pass. We bartered tobacco and some old shirts for articles of their primitive industries.

They came to fish in numerous gangs, bearing their picturesque folding nets on two long canes, and presented an interesting sight as they dived with the nets in the pools, remaining a long time under water.

From km. 808 the river changes; the banks and the bed become more irregular, the high banks of the old bed of the river retire, and in the banks of the present channel can be seen the section of the channel of the old river. An example of this is found above the promontory km. 810.7 where the river flowed formerly as shown on the annexed map, crossing almost perpendicularly the direction of the present bed. It is interesting to see here the existence of the complete section of the old river shown by a break in the continuity of the high banks of the present river.

Nov. 27th. Kms. 824 to 828.

I began to notice the presence of sharp, fine sand mixed with earth in the cracks and cavities of the hard "tosca".

On account of the loose and sandy composition of the ground there seems to be an increasing tendency in the river to make great bends and to change and reform its course.

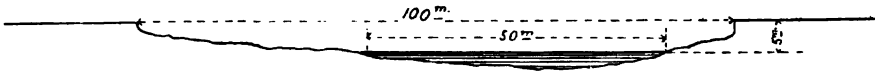
In these parts also there exist many remains of very old indian pallisades, mementoes of ancient fishermen, constructed and gone to decay during perhaps thousands of years. The probability forces itself on one, that the instability of the channel of the river is due to the combined action of nature and of man — the little cohesion in the components of the soil deposited by the capricious river itself, the very slight incline, and the obstacles erected during centuries by the indians.

Just now there must be few indians in the region we traversed today, to judge from the abundance of algaroba beans left untouched.

On a bank we saw a large "brea" on whose trunk had been carved some symbolical figures, perhaps as a sign or warning to the indians using the more or less worn tracks, which almost everywhere follow the river on both sides.

Nov. 28th. Kms. 828 to 843.

The section of the river in these parts is generally as shewn below.



In the afternoon the water began to rise a little.

Again we met many Matacos indians. They collected on the river bank especially on the high parts, and I noticed that frequently they grouped themselves by families, the members of which seated themselves together.

The villages are generally at some distance from the river. The water supply appears to be a public matter, a kind of water works, consisting of a series of wells, sunk in the slope of the bank, where the turbid water of the river settles.

Nov. 29th. Kms. 843 to 858.

The river continues tortuous, in a general north westerly direction, which according to the route map should take us to the neighbourhood of Buena Ventura, as indicated by Astrada and Asp in their maps.

Some Matacos indians came along with us and helped to tow the boats. They are, as I have already remarked, enemies of the Pilagas and Tobas and also of the Chorotis. It seems that the only allies are the Pilagas and Tobas, a fact which also has been stated by Governor Luna Olmos in his book. All these tribes have a separate language and do not understand one another; the language



Upper river Pilcomayo.- Promontory, kilometre 810.7. View up stream

of the Matacos, characterized by a special guttural intonation, is monotonous and although not disagreeable, becomes tiresome. The Chorotis speak more energetically and make more use of *s* and *ch*.

The Matacos grow water melons, pumpkins, melons, corn and even tobacco on the ridge.

Nov. 30th. Kms. 858 to 872.

We pursued our monotonous course up the river, no variation—the same bends, the same banks, the same loose soil and the same vegetation on the shores.

The distance in a straight line which we had to cover was more than doubled owing to the innumerable turns in the river. These are not well known even to the indians, who designated the distance in a straight line which we had still to go before reaching Buena Ventura as so many “dormes” (night sleeps), or day’s travel by the path which runs more or less parallel to the general course of the river. We pushed on as hard as we could but always there were the same “dormes” wanting.

Dec. 1st. Kms. 872 to 886.

Cloudy day, some rain during the night.

At midday we reached the Paso del Tigre, where there is a large indian village on the south side of the river. The inhabitants were in full “aloja” festivities and we saw several couples cross the river bringing big bundles of the valued algaroba fruit as their contribution to the feast.

In the afternoon there came a Mataco interpreter, accompanied by many indians, saying that he had been sent by Mr. Domingo Astrada to offer us his assistance, subject to our agreeing to pay him tobacco and food. I was annoyed at the “subject to” and sent him away rather roughly. But regretting this afterwards, I sent for him and agreed to accept the services of himself and two others to tow the boats; but “he did not work, only ordered”. He sent us two of his men, who behaved well.

Past kilometre 800, more or less, where the river no longer runs in a well defined bed with continuous banks on both sides, the upper river Pilcomayo presents the same characteristics as do all the rivers of the northern portion of the great continental plain—without defined edges, with an irregular succession of great and small bends, sections more or less short with high banks on one or other side alternately, in parts, shores greatly extended with a little tortuous channel of small section and low banks—the exception to these general features being occasional gullies, due to the presence of harder ground, with greater incline which produces rapids and

falls at times of low water. At the turns of the bed, worked out of the harder material are frequently found pools of considerable depth.

This instability, during a very long period of time—a geological age—explains the presence of sections of former channels, perfectly preserved, which can be seen in the present high banks.

Dec. 2nd. Kms. 886 to 899.

Cloudy, drizzle and later on, rain.

The river now appears with less tortuous reaches, towards the desired direction—north.

We had already entered the domains of the Buena Ventura colony and passed the houses of the colonists Antonio and Echave, who with their families were waiting for us and saluted from the top of the bank the advance of our gaily decorated boats, which approached rapidly urged on by the joyful and enthusiastic crew who had dressed as well as possible with what little was left to them of sound and clean clothes.

At last about noon we landed in front of the house of the administrator of the colony Mr. Domingo Astrada, who with his amiable family and his friend Mr. Sandalio Moyano received us with all possible attentions and with that frank and friendly hospitality which increases in direct proportion to the distance which separates the home visited, from the great centres of civilization.

The Buena Ventura colony has been established and continues to progress, thanks to the efforts and energy of its present administrator Mr. Astrada. It is a national colony under the "Dirección de Tierras fiscales de la Nación" (National Board of Fiscal lands) and so far as we could ascertain its site has been well chosen. The climate is good, dry, not too warm and what is very important, there are few mosquitoes or other troublesome insects. The soil is good, with abundant pasture and in the woods some distance from the river there is plenty of wood for building purposes; "palo santo", "algarrobo" and "quebracho", red and white. For light work there are willows and "alisos" which here are called "boba".

The colony belongs to Department N° 12 of the Territory of Formosa and contains 30 families of colonists each occupying a lot. The total population, according to Mr. Astrada is about 1000 souls, inclusive of colonists, servants, intruders and squatters on fiscal land on the outskirts of the colony.

The administrator complained that the colony had not yet been provided with the institutions corresponding to its importance, there being no police, justice of the peace, post office, schools or roads—



Camp in Buena Ventura.

the only road being one to Florencia on the river Bermejo, which had been made at the expense of the colonists.

The colony is devoted exclusively to raising cattle and consequently prices of all other articles are exceedingly high, as the cost of carriage for long distances has to be included. As high as \$ 50.- paper money (£ 4-7-3) is paid for a sack of maize and \$ 1.— for a kilo of sugar.

They have had three years of almost continuous drought and Mr. Astrada said that when we arrived, the river was about at its lowest.

Dec. 3rd. Buena Ventura. Km. 899.

Not having found any news of Mr. Casanova's expedition when we arrived at Buena Ventura, I sent a messenger to find him and learn if we could be of assistance to him.

I occupied the day with correspondence, advising the syndicate in Buenos Aires that we arrived safely at the point fixed for the termination of the journey and at the same time saying that in view of the relatively short distance that separated us from parallel 22", the limit with Bolivia, and having on the other hand been able to complete the study of the navigability of the river in the ascent thanks to the low water, I had decided to continue our study as far as beyond the frontier in order to survey the river Pilcomayo in all the portion that belongs to the Argentine Republic.

In the afternoon Mr. Casanova arrived on horseback, having left the cart some 20 to 25 leagues down river on the border of a lagoon near the Pilcomayo. He had not been able to get the cart any further, on account of the difficulty of opening a road for it and of the want of potable water.

We had not the pleasure consequently of welcoming all the land convoy. It would naturally have been of interest to indicate the course of the cart road from Clorinda to Buena Ventura. According to Mr. Caceres' opinion this road should go in a south westerly direction from the lagoon Pico Blanco or Nogot Poicoibi and make a great turn to avoid the dense forests to the south of the Pilcomayo; whereas Mr. Casanova, forcing his way to the north west, followed the longitudinal depression which, thickly wooded and without fresh water runs, as already stated, for long distances parallel to the river.

I have not been able to locate with precision the spot where Mr. Casanova left the cart but I estimate that it must have been on the edge of a lagoon somewhat to the NW of Santiago's village, shown on the annexed map, so that as may be seen, there was

little wanting, compared with the distance traversed, to reach the colony. It may be considered therefore, that without great difficulty communication may be established by means of a cart road along the river Pilcomayo, following the tracks of our cart, whilst avoiding occasional, very low and swampy marshes and keeping, as a rule, to the high land.

Dec. 4th.

I began the work for placing the hydrometric gauge and determined the volume of water in the river by reference to said gauge. The river fell during the day only 1 centimetre.

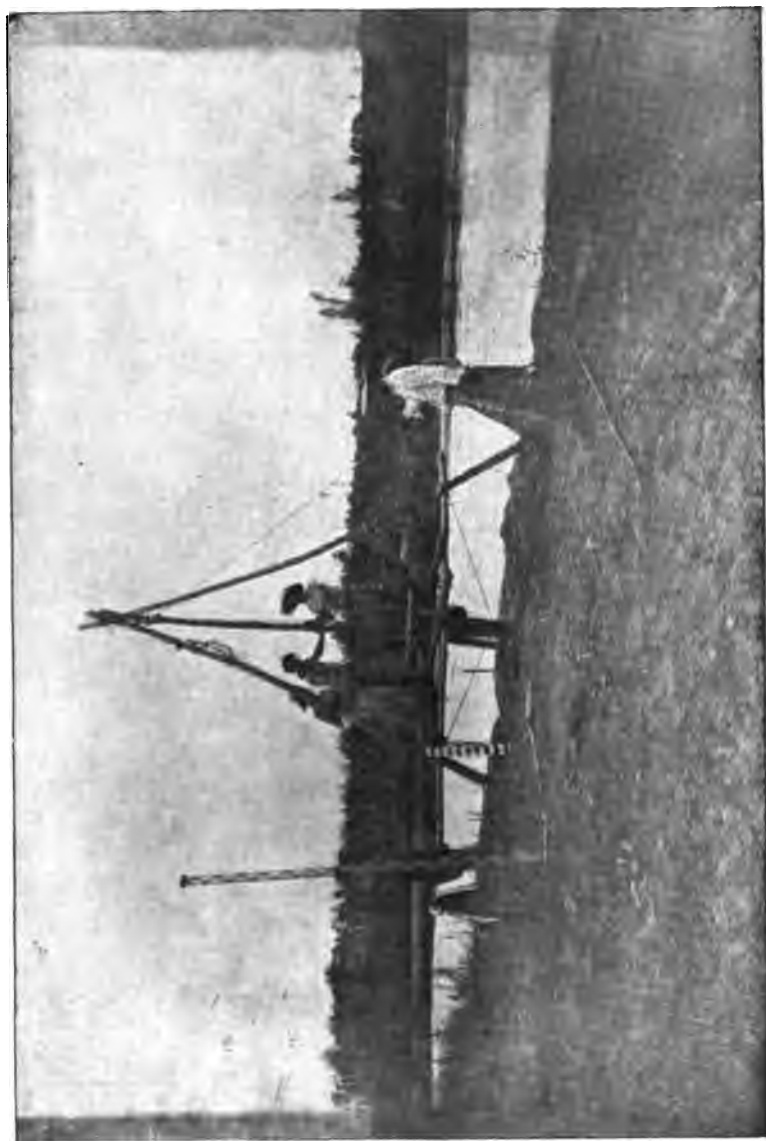
It being impossible to find a spot in the essentially alluvial bottom of this river wherein to secure the lower portion of the gauge, I decided to divide it into portions of 1 metre long, until reaching the highest solid bank. The bank is 5.38 metres high over the level of the water as observed by us, so accepting an ulterior fall of 60 centimetres, a scale at least 6 metres long became necessary.

Dec. 5th, 6th and 7th.

I finished the work of placing the gauge, having driven the first stakes of hard wood three metres into the ground by means of an improvised pile driver, and the others, two metres down, strengthened by a wooden cross below. Notwithstanding the solidity of this arrangement, I had an impression that it would not last long, and now at the time of writing this, I receive the news from our observer at Buena Ventura that a not very high freshet has carried away the three lower stakes, which means all the bank into which they were driven, and that afterwards when the river fell a similar bank had been gradually formed in the same spot, of fresh materials brought down by the river and deposited proportionally to the diminution in the velocity of the current. I mention this as an illustration of the instability of the Pilcomayo at that part, where any rise alters the shoals and changes the section of the river bed.

From a bend in the river, in front of Mr. Astrada's house, there frequently come loud noises caused by the fall of great masses of earth into the water which washes away the base of the bank.

I have just completed a set of instructions for the use of those in charge of the hydrometric gauges, recommending them in similar cases to make use of the "movable" system employed by the prefectures in the principal rivers, which consists in the use of a stake divided into decimetres which is driven into the bottom and moved and replaced according to the fluctuations of the river. The rises or falls are added or deducted as regards the previous obser-



Upper river Piocomayo. Bucua Ventura. - Pile driver for construction of hydraulic gauge.

vation of the state of the river, having already, by simple levelling, found the relation between the height of the water at a given time and the standard points of reference on firm land.

At night on the 5th December I determined the geographical latitude $22^{\circ}42'4''$ S by observation of the culmination of four stars.

Mr. Astrada told us an item of interest respecting an obscure point in the accounts of the expedition under Ibarreta—where the boats remained? He said that some indians whom he and his companions met when going across the Chaco much higher up than the Estero Patiño, offered to take him to the place where the remains of the boats were buried. At all events it is strange that the boats should have been able to pass from the upper Pilcomayo to the Dorado river without any of the survivors of the expedition, in their narratives, having said anything about an extraordinary freshet on the spot. Later on our Mataco guide told me that in the year Ibarreta passed, the river rose very much, "*covering the quebracho forest and killing many indians*".

Dec. 8th.

During the time occupied in placing the hydrometric gauge and making other studies in the river, Mr. Cáceres was employed in trying to get together the additional animals requisite for the return to Clorinda of the greater part of the expedition and for the journey to Ledesma of the division which, under my orders, should prosecute the navigation of the river as far as parallel 22° .

I decided to take with me Mr. Oscar Mayer and seven men and had the provisions and equipment put into the two smallest boats. One of the large boats was left in the care of Mr. Astrada, whilst the other was to be used by part of the division which was to return by way of the Chaco.

Dec. 9th. Kms. 899 to 901.

The river fell 2 centimetres during the night.

In the afternoon all was ready, and after having taken leave of Mr. Astrada and his family and of our travelling companions Messrs. Cáceres, Casanova, Ayala and Cáceres junior, and shaken hands with all the men who should go back from here and who during the journey had shown much good will and endurance, we took to the boats, I with Mr. Mayer and six men selected from among many who volunteered, wishing to take advantage of the opportunity to become acquainted with part of Bolivia and Salta, in the round trip by Yacuíva, Ledesma and Buenos Aires.

The river continues with many turns in very loose sandy soil in an irregular channel.

Dec. 10th. Kms. 901 to 914.

The river still very turbid.

At midday we arrived at the celebrated "Horqueta", the junction of the present southern branch, (also called the river Ferreyra) and the old or northern branch. About 5 years ago major Ferreyra discovered the branch named after him and which then had very little water. The northern branch was at that time the principal one, and the two in various channels united up river from Tronquitos. Little by little the fall which supplied the water to the river Ferreyra worked back, whilst the channel became deeper and received more water, the northern branch on the other hand drying up except in times of high floods.

The bottom of the northern branch was, when we passed, 1.5 metres above the level of the water in the river Ferreyra and covered with "bobadal" but it is not impossible that in some great flood, the river in the southern branch, owing to some obstacle, may turn again into the old channel or perhaps abandoning both, form a new one.

All day long the heat was intense, the north wind feeling like the blast from a furnace.

We passed the night at Rosario, the ranch of the colonist Santiago Bañagasta, who has a piece of cultivated land on the opposite side of the river. It may be noted that his means of communication between his house and the field is by swimming, as he has neither boat, raft nor dugout.

Dec. 11th. Kms. 914 to 929.

Cloudy.

The river was at normal height, the water reaching exactly the line of aquatic vegetation.

The Argentine coast is well populated, up river from Mr. Astrada's house.

I could see that in some former freshet the river had deposited a layer of more than one metre thick. For the first time I noticed a decided incline in the strata on the banks, probably due to some local collapse.

From Mr. Astrada's house I took with me an interpreter, Camargo Gomez and two Matacos to assist in hauling the boats. Camargo, Ciruano indian, came from Yacuiva to the borders of the Pilcomayo several years ago. He married the daughter of the Cacique Salteño and is now himself a cacique; he is a good interpreter, astute and indomitable like all the indians.

The Matacos are at war with the Chorotis, so it was curious

to see the haste in which some Chorotis, fishing round one of the bends in the river, fled on seeing some of their Matacos enemies accompanied by christian forces.

Camargo says that the indian tribes are distinguishable not only by their language but by the different manner of painting themselves. The Chorotis paint the face across, whilst the Matacos prefer vertical lines with a cross on the brow. They must have other distinguishing marks, for when I asked Camargo if he could always recognize if any indian, he might happen to meet, were choroti or not, he only smiled, as if surprized at the question.

We had reached the region most thickly inhabited by the Chorotis. Groups of them appeared high up on the banks in an attitude of suspicion with bows and arrows, partially hidden behind trees. Camargo told them to lower their arrows which they did, asking where we were going to. On hearing «to the Fort», they answered "bueno" (all right).

At night we heard exceptionally numerous cries of owls and partridges. The Chorotis were on the alert watching us. Camargo said that the Chorotis imitate the cries of owls, charatas, partridges and other birds because they are "rascals and tigers" whilst the Matacos have no need to do this, because they are good and peaceable.

The Chorotis and Matacos are mortal enemies; the former having killed the father and mother of the cacique Salteño, so as Camargo said "How can there then be peace?"

Dec. 12th. Kms. 929 to 944.

Cloudy. Strong wind from the north.

The river was more or less in normal condition, having remained according to information we received, with little change for the last three years.

In the morning a Choroti indian on the bank shot an arrow at Camargo who went in front assisting to tow. He picked up the arrow which fortunately did not hit him and threw it into the water. I saw nothing of this as I was engaged in taking measurements and as I was not told of it at the time, I lost an opportunity of scaring the Chorotis by letting them have a remington volley over their heads.

At breakfast time we were visited by a numerous group of Chorotis all armed with bows and many arrows. At first two appeared and then as by enchantement 20 to 30 more, followed by the cacique, a short man with a vivacious look, wearing a big soft hat. They grouped themselves in a semicircle nearly surrounding our little cooking fire on the bank, scrutinizing us and passing remarks. It was somewhat annoying to receive this armed visit

during our time of midday rest in the great heat, so I gave orders to use redoubled vigilance with regard to the boats and cargo, whilst Camargo who speaks some choroti exchanged some phrases with the cacique. It was interesting to watch the eyes of the Matacos and of the Choroti warriors as they looked at one another. Camargo behaved well, although it was easy to see that he and his two companions were very much afraid, the old matabaco seized a remington whilst the young one sat down by a tree and did not even raise his eyes. The old chorotis and more especially a young one with a bull-dog face glared at the three matabacos like wild beasts, ready to spring at them. They showed no animosity towards us "christians". Camargo asked them in my name why they prepared their arrows and came stealthily upon us, adding that when they wanted to visit us they must leave their arms behind, and to give force to his words he also took a remington from one of our men. At last he made them comprehend, always in my name, that they must withdraw as we were about to breakfast, and so they did. As a sign that they withdrew peacefully and without evil intentions they left us some arrows in exchange for tobacco, but they would not part with their bows. In the afternoon they calmly looked at us from a high bank where their village doubtless was.

After the indians had gone away Camargo told me about the arrow which had been shot at him and that his enemies the Chorotis had recognized him.

The wind continued blowing hard from the north with a densely clouded sky and an extraordinary fall of the barometer threatening a storm, and at 9 o'clock the wind rose to almost a cyclone from the SW bringing dust that penetrated everywhere, followed by a deluge of rain.

Dec. 13th. Kms. 944 to 954.

Rain and strong wind.

The river rose 36 centimetres during the night.

In view of the attitude of the Chorotis the day before, I gave orders that I should be told at once if anything happened and that no action should be taken without my express orders. Only in the event of being attacked, when alone, should any one to defend his life use a weapon.

The river continues tortuous with irregular banks, great spreads and shoals and narrow channel with many turns.

The rise in the river favoured us greatly on the shallows. The river is incessantly at work demolishing its banks and forming shoals so that every now and again in times of sudden rises, the

noise of masses of earth falling from the bluffs into the river can be heard.

In the Santa María store Mr. Mayer procured some vegetables in exchange for remington cartridges which are much valued by the colonists who require them to make themselves feared by the Chorotis who cross the river and rob cattle.

Dec. 14th. Kms. 954 to 961.

Cloudy.

The river continues rising and has become broad and imposing.

We started early and reached the Bolivian fort Guachalla at 7 a. m.

On turning out of the last bend into a reach of about 800 metres long, we suddenly saw the houses and huts of the fort where they expected us and saluted with their flag.

The Colonel Emilio Armaza received us very cordially praising us more than we deserved for our "exploit" as he styled it, and told us that some days before he had thrown a bottle into the river with a salute to us which we had not been fortunate enough to find.

The fort is a little quadrangle of about 100 metres formed of a double palisade of thick alisos packed with mud and with towers at the corners. Within this are the houses and sheds.

The Colonel's house is rather well built, raised on strong willow trunks two metres above ground, with a commodious flight of steps, corridor and large well ventilated room.

The garrison consists of 2 chief and 2 subaltern officers and 80 cavalry soldiers armed with Winchester carbines, and provided with good horses. They were waiting for reinforcements to advance further down river and erect, for the present, one fort more in front of Mr. Domingo Astrada's house.

In reply to my question—how far do Bolivia's pretensions extend?—the colonel replied "as far as Paraguay".

The prefect of Tarija, Dr. Trigo had made an expedition the past year as far as the Toldería de Tronquitos and was now preparing to extend his exploration as far as the Estero Patiño, establishing forts at intervals.

Colonel Armaza offered to assist us with animals, saddles and gear for the march with our equipment as far as Caiza or Yacuiba, where we would be able to procure the necessaries for continuing our journey to Ledesma.

This very friendly offer I was glad to accept.

In the afternoon I arranged a provisional hydrometric gauge and the Colonel promised to take daily notes of the height of the water.

After having taken some views of the fort and groups of officers and soldiers we continued our journey by river, agreeably impressed by the hospitality we had enjoyed.

I determined the latitude of Km. 960.6 — 22° - 27' - 22" S.

Dec. 15th. Kms. 961 to 974.

We passed the station Alto Alegre and the house of Marcelino Torres. A messenger sent by Mr. Domingo Astrada overtook us with mails and gave us the news that the Chorotis today in the early morning had assaulted the station Santa María, situated almost in front of the fort Guachalla, surprized the family there and wounded the two men Absalon Gallo and Joaquin Moreno. These had made a good defence, having killed one and wounded several indians; the rest took to flight carrying off their wounded and several mares.

The messenger set off for the nearest store in search of remedies for the wounded "christians".

The river which had fallen a little during the night remained stationary during the day, the muddy water reaching the line of vegetation.

We noticed great numbers of jumping locusts which had fallen from the bluffs onto the dry shore and were devouring one another, causing a stench that polluted the air.

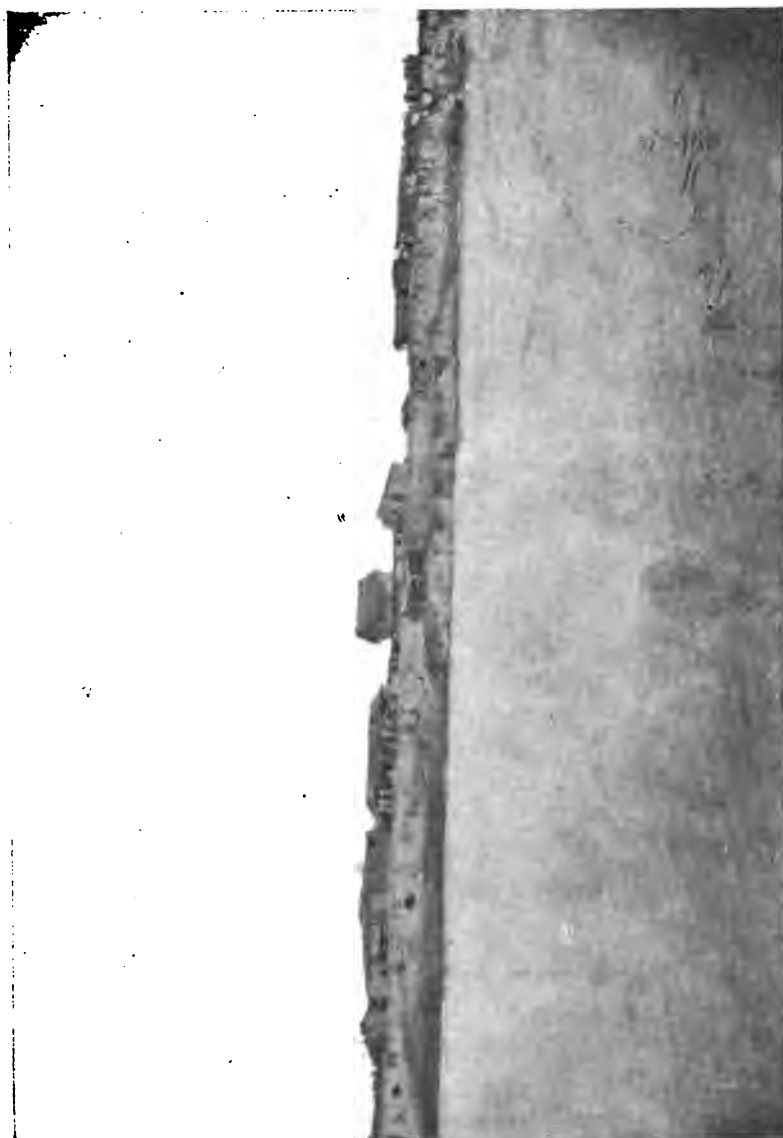
In the afternoon we saw two indians hiding behind shrubs on the bank. When they perceived that we had seen them, they came forward in a complete state of nudity and without arms. Camargo spoke to them and then he and they insulted one another, the Chorotis making very obscene gestures of contempt. They asked Camargo if he was coming back that way, to which I told him to answer "yes with the captain of the fort".

Later on we met a very rustic wooden raft in charge of some Tobas indians under the cacique Taicobi bringing melons and other cargo, the nature of which we could not discover.

At night we were visited by two colonists who complained of the behaviour of the Chorotis who rob cattle and the produce of the gardens and amuse themselves by shooting arrows at cows and horses. In front of every "christian" settlement there is always a village of indians, who neither till the soil, nor fish, nor hunt, finding it more convenient to live on the waste and garbage of the settlement and to beg, or steal. If they do not get enough in these ways, they fall back on roots and such fruits as they can find in the woods.

I have been assured that the indians eat locusts raw and I have seen them eat wasp's honey-comb with the larvae in the cells.

According to their ideas, they are of course right in considering the "christians" as enemies and intruders to whom they ought to



Upper river Pilcomayo. — Fort Guachala.



Fort Guachilán. Soldiers and Indians.

do as much harm as possible. They are in the habit of gathering on the bluff and have been known to cry out to the "christians" opposite: «This land is ours, why have you come here?» The judicious colonist who in his heart admits that the indians are right, tries to come to an arrangement with them, finding out to which cacique the lot, so liberally sold to him by the National Government, belonged, and buying out his rights for a mare, a cow and a few sheep.

Dec. 16th. Kms. 974 to 988.

As we continue our ascent towards the NW and approach the higher regions at the foot on the eastern slopes of the Bolivian mountain ranges, we perceive marked characteristics in the river, consisting in augmented section, greater volume and increased erosive and destructive force. The reason of this is, that after the Pilcomayo issues from the deep cañon in which it crosses the Caiza range of mountains up stream from the town of San Francisco, its waters gradually diminish by absorption in the soil and by evaporation, without receiving any affluents before disappearing in the Estero Patiño.

In the afternoon some Choroti indians came swimming alongside to beg tobacco and cloth. I let them know that we would not give them anything because they, or their companions, had attacked the "christians".

We passed the night on the land of the colonist Alejo Diaz who received us very hospitably, offering us meat, milk and vegetables. One of his labourers Manuel Arrabana had a hand bandaged, having been wounded when bathing a horse, by a Choroti who treacherously shot an arrow at him from behind the trees. He made me a present of the arrow with an iron head which later on I have had the opportunity of presenting to the Minister of Agriculture as an illustration of the dangers to which Argentine colonists are exposed in those remote regions, because of insufficient police or military forces.

Dec. 17th. Kms. 988 to 997.

Cloudy.

The general declivity in the land seems more pronounced and the river has a stronger current and is more turbid.

We passed La Esperanza, the house of Mr. Diaz and at noon arrived at Nuevo Porvenir, the first store on the river bank, belonging to Mr. Manuel Cejas, who had news of our approach and received us well.

Mr. Mayer being rather unwell with a good deal of fever, I decided to remain in Nuevo Porvenir and let the sick man rest in.

a good bed under the hospitable roof of Mr. Cejas. Fortunately next day he was all right again.

But the Nuevo Porvenir is a *pulperia* (place where spirits are sold). It was impossible to prevent our men, after the long period of total abstinence they had passed through, from getting thoroughly drunk, fighting and creating a disturbance. It was with great difficulty that I could keep them together and get them to go to sleep so as not to lose the next day. I had to do sentry duty all alone, seated on the bluff until early morning, watching my boats, because I could not risk the possibility, being so near the intended termination of the journey, of some choroti swimmer quietly cutting the ropes and making off with them.

Dec. 18th. Kms. 997 to 1009.

Cloudy with drizzle.

We traded with the Choroti tribe of the cacique Cara-Cara, exchanging tobacco and cloth for a great many arrows and some bows. They brought bundles of from 10 to 15 new arrows with hard wood points, of which it appears they always have a large number ready.

We took breakfast at La Valle, the land of the Ponce family. Mrs. Ponce said that she had not had any trouble with the indians and that they had neither robbed nor done any other damage. I believe that the reason was that the lady, who seemed very clever and determined had managed to gain the good will of the indians, affording a proof that the nature of the relation between the two races depends a good deal on the behaviour of the christian element.

Higher up on the SW side of the river there are other Matacos (Montaras) indians who are friends with the Chorotis, intermarrying with them.

There is a rather large scattered christian population on the Argentine side of the river; there being many cultivated patches on the banks. The forest on the ridges is almost entirely made up of "alisos". The plague of dead locusts still exists with its accompanying fetid odour.

Dec. 19th. Kms. 1009 to 1025.

Cloudy, with a little rain.

There are many indian fishing weirs on the salient points of the banks.

The fall in the river has exposed many mud banks where the men towing, sink to the arm pits, which greatly impedes our progress.

Dec. 20th. Kms. 1025 to 1042.

In San Luis we met several colonists led by Mr. Astrada, who



Upper river Pilcomayo. — Port Nuevo Porvenir.

was taking steps to prepare for operations in consequence of the assault of the Chorotis on the Santa María station on the 14th of December. The cacique Salteño when he heard of it, had presented himself to Mr. Astrada offering his cooperation with 80 Matacos indians to attack and punish the Chorotis.

Our interpreter Camargo, after a confab with his father-in-law Salteño, presented himself at midday and said that he and his companions could not accompany us any further, declaring that they were afraid to go further away from the territory of their tribe, but the truth was that they wanted to take part in the campaign with Salteño and get a share of the possible booty.

The river continues with very long and broad reaches and alternating portions with many turns. Continually great masses of the bluff fall into the river, the noise of which is heard a long way off. Changes in the channel of the river must consequently be effected within short periods.

At night I took the geographical latitude and the declination of the compass (Latitude $22^{\circ}-12'-22''$ S).

Dec. 21st. Kms. 1042 to 1057.

In the afternoon the river began to rise rather rapidly, covering the shoal banks and the pools where the water had settled, with its turbid chocolate coloured stream. The ledges in the banks that served as a footing for the men to tow from, were flooded and the increased current retarded the navigation.

There must be plenty of cattle in the fields on both sides of the river, to judge from the slopes cut out of the bluffs in several places down to the water's edge. We also noticed more fishing weirs and indians engaged in fishing; perhaps because in this part of the river fish are more plentiful.

Dec. 22nd. Kms. 1057 to 1069.

We saw and heard many earth-falls from the high bluffs into the river, which rendered it rather risky to approach too near in the boats.

The river brought down a great deal of rubbish and sticks, the water being very turbid.

In the parts where the river spreads, it assumes the appearance of a lake and in one of these may have occurred what Ibarreta's men reported: that they had been driven by a high wind onto the river shore.

With a rise of half a metre in this part of the river it would inundate the fields for more than a kilometre in width.

At the Ovejería they gave us the agreeable news that captain

Argandoña, sent by the commandant of Fort Guachalla with the necessities for our journey by land, was already awaiting us at the station El Hito belonging to Mr. Nicanor Centeno, near parallel 22°

Dec. 23rd. Kms. 1069 to 1083.

Cloudy. Very warm.

In the morning we were overtaken by the two men who were to take the eleven saddle animals we had bought in Buena Ventura to the station El Hito. According to them the distance in a direct line to El Hito was only four leagues. We understood that we were nearing the end of our slow and tiresome river navigation; but we already knew that distance in direct line and indian "sleeps" were of very little use in judging of the distance we had still to go by our tortuous and capricious river.

During breakfast a messenger from Farias Vera the commissary in Buena Ventura, brought us letters and papers, and the owner of the station El Hito came to visit us.

Later on it threatened rain so I camped early on a high bluff where there is a path used by the indians of a village near by. Indian men and women crowded around, having a good stare at us; they were dressed in christian fashion, which did not improve their appearance and made them look out of harmony with their surroundings. An indian with his plumes, his collar of shells, broad leather belt and bow and arrows, is a characteristic type and even fine looking and in complete harmony with nature; but dressed, however well, in christian fashion loses much and produces a sad and even comical effect. I remember the impression made on me by the second of the cacique Salteño — tall, thin, with soft felt hat, black coat, blue trousers and bare feet.

Dec. 24th. Kms. 1083 to 1090.

Cloudy and then heavy rain all the morning.

About noon there came the cacique Taicoli, with several indians, sent by captain Argandoña from the station El Hito to assist us. The weather having cleared a little we started, and making rapid progress reached the station, where the captain, who was waiting, joined us in the boat. With great enthusiasm we got over the distance still wanting to reach the intersection of parallel 22° S.

The river continues with irregular banks and exposed shoals, spread out in its valley of two kilometres in width, across which flows its tortuous stream.

The clearing which indicates parallel 22° was in some parts almost hidden by Caña de Castilla, only a narrow path being kept clear by cattle going down to drink in the river. Following this



Upper river Pilcomayo - Kilometre 1065.

path at 1650 metres distance from the river we arrived at HitoN° 1 (boundary mark) of the international limits.

We returned at once by water to the station El Hito, where I handed over the two boats to captain Argandoña and although it was already night, we took everything—equipment and provisions—to the station, where we pitched our camp within the enclosure and passed the night without any sentry, a thing we had not done for many months, with the exception of the few days we stayed in the house of Mr. Astrada.

Dec. 25th.

We made everything ready for the land journey. I received the animals bought in Buena Ventura, had our baggage arranged for transport on muleback, determined the relative position of the station to parallel 22°, and took a photograph of the boundary mark N° 1 and of the boats which had rendered us such good service. At night I took a good observation of latitude to compare with the data of the Boundary Commission, based on more exact observations taken with finer instruments than mine. The result was for the station El Hito, latitude 22°, - 1' - 24" S.

At the station El Hito we gave ourselves over to the care of the Bolivian captain Custodio Argandoña, and must declare that he amply carried out the instructions of colonel Amarza, taking us with all possible attentions by Crevaux, Colonia Vieja and La Peña to the Bolivian village Caiza, where we were very well received by the Prefect Fructuoso Mendoza and his family, who afforded us hospitality for several days and procured for us all that was requisite for the journey to Ledesma, terminus of the Central Northern Railway. We arrived there on the 11th January of this year.

In Ledesma we had the pleasure to see from the newspapers that Mr. Cáceres had safely effected the return to Clorinda with all the party and equipment under his charge; and on the 14th of January we were once again in Buenos Aires, where the men who had accompanied us as far as Bolivia, embarked for Formosa.



Upper river Pilcomayo, in front of the station El Hito.—View up stream.



Upper river Pilcomayo, in front of the station El Hito. --View down stream.



Parallel 22° -- Boundary N° 1.



River Bermejo.—Ford La Cañada

NUMERICAL DATA
RELATING TO THE COURSE OF THE RIVER

1. From. Km. 297.9 up to the Junction Pilcomayo-Dorado
 2. Arroyo Dorado or Tala, from Caldá to Nalaik.
 3. Channel Soret Satandi.
 4. Upper River Pilcomayo.
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I. — Navigation from km. 297.9 up to the junction Pilcomayo-Dorado.

DATE	Distance by river		Height of the banks (1)	Width		Rise or fall of river (2)	Soundings	Velocity in metres per second	OBSERVATIONS
	accumulated from the mouth	daily run		of the stream	of the channel				
1905	kms.	kms.	m.	m.	m.	m.	m.		
August 31	297.9	..	..	..	..	..	..	..	end of Sol's map. NW corner of Godoy's land. 126 kms. in direct line from the mouth.
	298.9	..	..	..	..	..	0.75	..	
	299.3	..	..	..	..	..	0.75	..	
	300.0	2.6*	..	..	..	..	..	..	*from 4 pm. «Camp, 31st Aug.»
September 1	300.2	..	..	..	..	+0	0.75	..	
	300.5	..	..	..	..	..	1.00	..	
	300.7	..	..	..	..	..	..	..
	300.9	..	..	..	..	..	1.25	..	
	301.2	..	..	20	30	..	1.00	..	
	301.4	..	..	20	..	..	0.50	..	
	301.7	..	..	25	..	..	0.75	..	trees Tataué, Manduvina. Timbó, Guayacán.
	301.8	..	4	..	..	..	1.00	..	
	302.1	..	..	..	..	..	1.00	..	
	302.5	..	..	..	..	..	0.75	..	more current, turbid water, embedded trunks.
	303.3	..	..	20	..	..	1.00	..	reef of <i>fosca</i> across river causing longer straight reaches.
	303.8	..	..	25	..	..	1.00	..	
	304.2	..	..	..	..	..	1.00	..	banks less abrupt.
	304.3	..	..	..	..	..	0.60	..	
	304.8	..	..	25	..	..	..	..	embedded roots, exposed shoals.
	305.6	..	..	..	..	..	1.00	..	little water, in parts many twists and turns in channel.
	305.8	..	..	..	..	..	0.75	..	
	306.7	..	..	15	..	..	0.50	..	high bluffs, loamy, little filtration.
	306.9	..	..	..	..	..	0.75	..	
	307.2	..	..	..	..	..	0.60	..	river turbid, embedded trunks, narrow channel, tortuous.
									« Abandoned Franciscan Mission », 134 kms. in straight line from mouth.
									Brook from the Argentine side.
	307.6	..	..	..	..	..	0.50	..	reef of <i>fosca</i> across river.
	308.5	8.5	..	20	..	..	..	..	hard banks. «Camp, 1 Sept.»
2	..	..	..	30	40	+0	1.00	..	
	310.8	..	..	10	..	..	1.00	..	reef with rapid.
	311.3	..	5	15	..	..	0.75	..	harder banks of sandy loam and soft <i>fosca</i> , brook from the Paraguayan side.
	313.0	..	..	18	..	..	0.50	..	bottom of very irregular hard <i>fosca</i> , brook from the southern side.
	315.7	..	..	25	..	..	0.50	0.45	
	318.2	..	..	15	..	..	0.50	..	reef with declivity.
	319.0	..	..	..	..	..	..	..	embedded trunks.
	319.5	..	6 4 7	..	..	..	..	..	reef of hard <i>fosca</i> .
									Quebracho, jacarandá, guayacán, manduvina.
3	321.4	12.6	..	12	..	..	..	..	«Camp, 2nd Sept.»
	324.5	..	6 4 7	8	..	+0	0.50	..	shoal, probable waterfall in lower water.
	325.7	..	..	10	..	..	..	..	many fresh water brooks, especially from Paraguayan side.

(1) Over level of water.

(2) During preceding night.

DATE	Distance by river		Width			Soundings	Velocity in metres per second	OBSERVATIONS
	accumulated from the mouth	daily run	Height of the banks (1)	of the stream	of the channel	Rise or fall of river (2)		
	kms	kms.	m.	m.	m.	m.	m.	
September 4	325.7	..	..	..	..	..	0.50	low water, bed full of tree trunks, a little waterfall.
	327.2	..	..	10	..	..	0.50	rapid over hard reef.
	329.0	7.6	..	..	..	..	..	«Camp, 3rd Sept.»
	329.3	..	..	24	..	-1 c.m	0.75	many <i>raigones</i> , banks 7 metres.
	329.8	..	..	..	..	..	0.75	fall of more than 1 metre formed by <i>fosca</i> .
" 16	331.1	..	..	..	..	..	0.50	on both sides of river there is hard <i>fosca</i> which causes the curves in the channel.
	334.1	..	..	12	..	..	..	fall over <i>fosca</i> , rapids.
	334.2	..	..	12	30	..	..	banks of hard <i>fosca</i> .
	335.8	..	..	..	..	..	0.45	<i>raigones</i> and long shoal.
	336.7	7.4	..	30	40	..	..	«Camp, 4 Sept., Baradero.»
" 17	..	..	..	..	..	-0.07*	..	* from the night of 4th Sept. to morning of 16 Sept.
	338.6	..	..	..	..	..	0.50	high banks of hard <i>fosca</i> on Paraguayan side. At salient bends sand points. Woods sparser and poor.
	339.9	3.2	..	20	30	..	0.50	many <i>raigones</i> , in some parts strong current, in others deep stretches with little current.
	341.0	..	..	25	..	..	0.45	«Camp, 16 Sept.»
	341.6	..	..	15	..	..	0.45	rapids over hard <i>fosca</i> and stones.
" 18	342.4	..	..	..	..	..	..	brooks from Argentina with fresh water, many <i>raigones</i> .
	343.8	..	..	..	..	..	0.50	<i>raigones</i> and rapids.
	346.5	6.6	..	8	..	..	0.36	many <i>raigones</i> .
	347.2	..	..	10	..	-0.01	..	rapid over hard <i>fosca</i> . «Camp, 17th Sept.»
	348.8	..	..	12	..	..	0.35	rapid over reef of lumps of <i>fosca</i> , height of fall 1.5 ms.
" 19	350.6	..	..	20	..	..	0.30	fall over stones, <i>raigones</i> and banks continue.
	352.9	6.4	..	8	..	..	..	<i>fosca</i> shoal, still more reefs.
	354.3	..	..	25	35	±0	0.20	«Camp, 18 Sept.»
	358.1	5.2	..	..	..	..	..	shallow rapids over stones, <i>raigones</i> and shoals frequent.
	360.4	..	..	15	..	±0	0.20	«Camp, 19th Sept.»
" 20	361.0	2.9	..	..	..	..	0.30	rapids caused by <i>raigones</i> .
	361.4	..	..	20	..	..	0.25	curious unevenness in <i>fosca</i> .
	361.7	..	..	..	..	..	0.20	more <i>raigones</i> and shoals.
	363.1	..	..	..	..	-0.01	..	«Camp, 20th Sept.»
	363.4	..	..	..	..	..	..	rapids and shoal.
" 21	363.7	..	..	..	..	..	..	<i>fosca</i> reef in two steps. Rapids with fall of 0.50 ms., further on rapids over a sand bank and <i>raigones</i> .
	366.2	5.2	..	20	..	..	0.20	rapids.
	370.6	4.4	..	..	..	±0	..	rapids.
	..	..	..	..	..	..	..	rapids, reef, <i>fosca</i> very hard, almost sand stone.
	..	..	..	..	..	..	..	reef and shoal «Camp, 21st Sept.»
" 22	..	..	..	..	..	..	..	still more rapids over reefs, few <i>raigones</i> and tree trunks noticeable. The general incline rather pronounced, height of banks gradually diminishing.

(1) Over level of water.
(2) During preceding night.

DATE	Distance by river		Height of the banks (1)		Width		Rise or fall of river (2)	Soundings	Velocity in metres per second	OBSERVATIONS
	accumulated from the mouth	daily run	m.	m.	m.	m.				
	kms.	kms.	m.	m.	m.	m.	m.	m.		
September	23	375.5	1.9	8	20*	..	0.01	0.20**	..	Lowest depths 20 cms. «Camp, 22nd Sept.»
	24	379.6	4.1	..	15*	..	+0	0.20*	..	*mean **least. Banks higher, few <i>raigones</i> and tree trunks in bed of river. «Camp, 23 Sept.»
	25	380.2	..	..	15	40	+0	0.30	0.45	*least, reefs, rapids, shoals, <i>raigones</i> . «Camp, 24 Sept.»
		381.7	2.1	..	..	..	..	..	..	<i>tosca</i> reef in the form of a complete dam 30 metres long with an opening of total length 8 metres, and 0.30 metres depth of water. Depth above the reef 1.50 ms. Depth below the reef 2.70 ms.
										«Junction of the Dorado and Pilcomayo». «Camp, 25th Sept.»

2. — Navigation of the Arroyo Dorado from Paso Caldá as far as Nalaik.

October	18	438.2	..	..	70	..	..	..	..	Paso Caldá.
		442.0	..	..	..	..	2	..	..	Caldá channel ends and a narrow rapid brook begins.
		443.5	..	..	..	..	0.40	..	..	towards the NW a lagoon or shoal opens out, then follows a narrower channel full of <i>camulotes</i> .
		445.1	..	..	..	..	..	..	..	rapid of about 100 metres.
		445.9	..	1	..	..	2.50	..	..	banks begin to rise, channel better defined, very deep in spite of year of so much drought.
		447.5	..	..	..	..	..	..	..	banks increasing in height a dry water course or brook from the north.
		450.0	..	..	30	40	1.50	..	..	broad rivulet towards the north.
		452.1	14.2	..	..	..	..	..	..	open country. «Lagarik».
										an occasional fallen trunk, no big trees, on the banks only <i>chilca</i> . «Camp, 18th October».
	19	454.9	..	2 á 3	15	..	+0.08	0.70	..	«Ford Talaik», high banks from 2 to 3 metres. Palm groves towards south. A dry water course from the west.
		457.9	..	..	5	..	..	0.25	..	a little water winding in narrow channel, <i>tosca</i> reef, rapid with incline of 38 cms. in 210 metres.
		459.3	..	..	8	..	..	0.75	..	rapid, banks not so high, hard soil.
		459.9	7.5	..	..	..	..	..	..	Camp, Oct. 19th, Nirazat.
	20	461.0	..	..	10	..	+0	0.20	..	end of steep incline, reach of little water and current begins, banks lower.

(1) Over level of water.

(2) During preceding night.

DATE	Distance by river		Height of the banks (1)		Width		Rise or fall of river (2)	Soundings	Velocity in metres per second	OBSERVATIONS
	accumulated from the mouth	daily run	m.	m.	m.	m.				
	kms.	kms.								
	522.4	9.7	..	..	..	..	..	..	..	We made a dyke to raise level of water. «Camp, 1st November» «Nalaik in front of channel Soret Satandi».

3. Navigation of the channel Soret Satandi.

November	3	525.3	..	..	..	..	..	..	..	border of the channel Soret Satandi, in the surveyed line from the Dorado brook.
		525.8	..	142	25	26	..	2.5	..	well defined abrupt banks.
		526.3	..	..	..	..	..	..	..	occasional depressions in the banks which serve to drain the low swampy land.
		527.2	2.0	..	34	42	..	2.6	..	«Junction upper Pilcomayo and Soret Satandi». Lat. 24°-8'-40" S.

4. — Navigation of the upper Pilcomayo.

November	5	527.2	..	..	21	50	+0.06*	3.0	1.5	*since 3rd. Novr. strong rapid, banks 3 metres high.
		527.5	..	3	..	..	..	..	..	strong rapid.
		528.0	..	..	30	..	..	2.4	..	current not so strong.
		528.6	..	..	..	..	..	..	..
		530.0	..	..	20	..	..	2.5	..	banks lower, river fuller floods the low lands.
		532.6	5.4	..	..	35	..	2.0	..	«Camp, 5th Novr.»
	6	535.2	..	0	30	30	0	2.5	1.00	river overflowing somewhat, water reaching to the crest of the bank ridge.
		536.3	..	..	40	40	..	3.00	..	river wider, less current.
		537.6	..	..	..	..	..	..	..	dense woods on both sides, good deal of quebracho. Open country with patches of wood.
		545.3	12.7	..	..	..	..	3.00	..	river continues full from crest to crest, there are big <i>quebracho</i> tree trunks in river bed, in last portion much current. «Camp, 6th Novr.»
	7	560.0	15.6	..	..	25-50	..	2-3.1	..	river the same, we notice gradually a slow fall in the water, various long straight reaches. The woods on the borders denser, <i>palo santo</i> , <i>jacarandá</i> and great deal of <i>quebracho</i> ; from km. 544 there is a great deal of <i>chañar</i> on the waters edge. «Camp, 7th Novr. in the mud».
	8	571.8	10.0	0.1	1	20-60	-0.02	..	..	river keeps on falling, height of banks increasing from 10 cms. to 1 m. Seccion and consistency of the banks as before, earthy soil above and argillaceous <i>loesa</i> beneath.

- (1) Over level of water.
(2) During preceding night.

DATE	Distance by river		Width		Rise or fall of river (2)	Soundings	Velocity in metres per second	OBSERVATIONS		
	accumulated from the mouth	daily run	Height of the banks (1)						of the stream	of the channel
			m.	m.						
	kms.	kms.	m.	m.	m.	m.				
November 9	..	..	..	..	..	*)	..	A few <i>palo borracho</i> seen on the shore. Where the river spreads there are sand banks, a deeper channel meandering between the banks. -Camp, 8th November.
	577.6	..	..	..	40-60	..	2.6	*) the river fell a little.
	577.8	..	..	..	25	..	4.0	brook, affluent from the north with little current.
	577.9	..	..	..	..	..	..	another branch from the S. W. with the mouth blocked by the slime from the freshet.
	578.5	..	1.25	..	..	..	..	strong rapid with 4 ms. depth down stream and another small water course from the north. There is a sudden change of level in the ground, the forests of hard wood trees cease, being replaced by willows and <i>alisos</i> .
	579.4	..	..	..	35-60	..	2.6	the river spreads more out between abrupt banks with a deeper sinuous channel.
	584.6	12.8	1.5	50	75	..	1.75	smoother bed with strong current. To the SW extensive growths of <i>carrizo</i> surrounded by woods.		
	586.5	..	2	..	60-80	..	1.4	<i>alisos</i> and willows. -Camp, 9th November.		
	587.3	..	..	..	100	..	1.55	bank higher, the freshet has risen to within 25 centimetres of the top of the bank. Big abandoned <i>foldertia</i> on the northern shore. Bed of river spread out with shoals.
	588.6	..	..	..	35-50	..	2.3	the river divides into two branches: the one to the south 2 ms. deep and 50 ms. wide, the one to the north 1.75 ms. deep and 70 ms. wide.
10	592.6	..	..	18-45	45-70	..	2.5	the river once more in one channel
	593.1	..	2.5	..	..	..	..	forests only of <i>alisos</i> less abundant. The alluvial soil as elsewhere rests on a stratum of hard <i>tosta</i> .
	594.3	..	..	..	50	..	2.5	
	596.1	..	..	..	50	..	1.75	channel better defined with abrupt banks.
	597.4	..	3	..	40	..	2.35	rapid		
	598.7	14.1	..	..	..	..	3.0	<i>raigones</i> of willow trees, height of abrupt banks 3 ms. Towards the north about a league distant an elevation with high forest
	599.1	..	3	..	50	..	3.0	rapid of <i>raigones</i> and shallows. -Camp, 10th November.		
	600.6	..	..	..	..	..	4	open country, high banks; ms a few <i>timbo</i> trees to be seen.
	605.3	..	..	..	45-75	..	1.12	narrows.
							3.25	rapid, <i>chadur</i> abundant.		

(1) Over level of water.
(2) During preceding night.

DATE	Distance by river		Width		Rise or fall of river (2)	Soundings	Velocity in metres per second	OBSERVATIONS
	accumulated from the mouth	daily runs	Height of the banks (1)	of the stream	of the channel			
	kms.	kms.	m.	m	m.	m.		
November 12	606.1	..	..	..	..	..	..	channel from NE of little depth.
	607.8	..	..	..	..	..	..	1.5 kms. to the south east extends a wood of <i>aliso</i> trees skirting the lagoon Pico Blanco, alias Nogot Pocoibi.
	612.7	..	..	..	..	..	..	rapid, hard <i>fosea</i> .
	614.2	15.5	..	..	..	..	..	«Camp, 11th Novr.»
	..	..	..	..	..	0.04	..	
	624.9	10.7	4.5	..	50-80	..	1.6 Δ 3.6	banks higher over water, with ledge left by the last freshet. The current as a rule does not exceed 1 m. per second. Open country with clumps of forest of little value. «Camp, 12th Novr.»
	
	
	
	
November 13	637.4	12.5	4	25	40-50	..	1.15 Δ 2.5	the banks 4 ms. high, the freshet had risen 2 ms. over the observation made. The country partly open with clumps of forest. Longitudinal depression on both sides of and parallel to the river. «Camp, 13th and 14th Novr.»
	
	641.3	3.9	..	..	50 Δ 100	..	1.5 Δ 3.0	in parts channel very broad with shoals, high banks. At various points current very strong «camp, 15th Novr.»
	
	650.1	8.8	..	..	40-80	-0.03	1.75 Δ 3.5	bottom hard, clayey, rendered smooth by the current. Banks high of harder material. The longitudinal depression follows the river at a distance less than 1 km. «Camp, 16th Novr.»
	
	650.4	..	..	..	50	..	2.0	rapid, hard bottom.
	651.3	..	..	..	55	..	2.2	banks in parts lower, many decayed trunks in bed of river.
	
	652.2	..	..	..	..	..	..	shoals in the curves.
November 14	652.4	..	..	..	80	..	..	deep pool suitable for a port.
	652.6	..	..	..	..	..	2.2	much spread out with deep bed.
	
	655.1	..	..	..	50	..	2.0 Δ 3.0	river very irregular with twists and turns, deep holes, bottom unequal with deep parts where the punting pole does not reach. Level country on both sides, with low woods, with open pastures, banks solid and abrupt.
	
	656.2	..	4	..	..	..	..	river narrower with strong current, banks 4 ms. high.
	657.6	..	..	..	40	..	3.5	on the northern side shore that allows of towing. River changes its character, narrower, bank harder and higher.
	
	659.3	..	..	..	50	..	3	fine deep cove.
	662.2	12.1	4-5	..	50	..	1.7 Δ 2.5	bank higher. Open country, «Camp, 17th Novr.»
November 18	..	..	..	..	..	0.05	..	river becomes more sinuous with close turns.
	666.5	..	..	20	35-55	..	1.75 Δ 3.5	narrows, curve very close, there

(1) Over level of water.
(2) During preceding night

DATE	Distance by river		Height of the banks (1)		Width		rise or fall of river (2)	Soundings	Velocity in metres per second	OBSERVATIONS
	accumulated from the mouth	daily run	m.	m.	m.	m.				
	kms.	kms.								
										being only 150 ms. of land between two curves in the bank there is dark chalk of greater consistency; many <i>raigones</i> .
	670.2	..	..	..	40-45	..	2.0	..	..	reef of hard <i>losca</i> , <i>raigones</i> .
	674.6	12.4	..	..	40-60	..	2.5	..	..	on the SW. a great lagoon, where the indians fish big, <i>surubis</i> and <i>viejitas</i> . Camp, 18th November.
November 19	..	..	..	..	..	-0.09	..	1.4	..	harder banks, earth black, chalky
	683.0	..	..	20-30	40-50	..	1.5	..	..	deep narrow channel with banks
	686.1	..	..	..	60	..	1.1	..	..	chalk bank in bed.
	687.2	..	..	..	55	..	2.5	..	..
	690.1	15.5	4-5	..	50-80	..	1.6	..	..	in proportion to the fall in the water the banks in the bed appear and gradually the channel becomes defined. Height of the bluffs over the water level 4 to 5 ms. Camp, 19th November.
							3.0	..	..
							3.5	..	..
20	..	..	..	..	..	0.04	..	1.0	..	hard chalky banks in river bed.
	691.5	..	..	..	50	..	1.0	..	..
	693.7	..	5	..	55	..	1.5	..	..	hard high bluffs.
	696.2	..	..	..	50	..	2.0	..	..	slopes of the banks fallen down and covered with <i>carrizo</i> and grass. Little current.
							1.5	..	..
							2.2	..	..
	698.2	..	..	..	45-45	..	1.5	..	..	bottom very hard.
							1.9	..	..
	701.8	..	6-7	20	40-50-65	..	1.5	..	..	high bluffs.
							2.0	..	..
	701.9	..	..	..	..	..	..	..	..	slopes of banks on both sides fallen down.
	703.7	..	..	..	50-60	..	1.4	..	..	hard red <i>losca</i> in the shoals.
							3.0	..	..
	708.0	17.0	..	..	60	..	1.0	..	..	less current. Camp, 20th November.
							1.5	..	..
21	..	..	..	..	..	0.04	..	..	..	bluffs up to 8 ms. high. Long reaches, less current. bottom level, slopes of banks fallen down.
	717.5	..	8-35	60	45-80	..	1.0	..	..
							3.5	..	..
	725.0	17.0	..	..	45-80	..	1.5	..	..	vestiges of palisades of indian fishing weirs, less current. Camp, 21st Nov.
							3.5	..	..
22	..	..	..	..	..	0.03	..	1.0	..	channel broad in the bends of the river, the salient point of the curves frequently with terraces. Soil harder, red. Gradually the section of the river augments. The river has fallen more or less to its normal condition, forming terraces in the high banks, natural wharves and towing paths, the water having retired from the parts of the banks that have grass or other vegetation growing on them. At km. 739 on the south western side of the river is situate the <i>lodge vie</i>
	736.6	..	..	20-40	60-80	..	1.2	..	..
							3.0	..	..

(1) Over level of water.
(2) During preceding night

DATE	Distance by river		Height of the banks (1)		Width		Rise or fall of river (2)	Soundings	Velocity in metres per second	OBSERVATIONS
	accumulated from the mouth	daily run			of the stream	of the channel				
	kms.	kms.	m.	m.	m.	m.	m.	m.		
November 23	743.7	18.7	..	20	45—60	..	..	1.0 ± 1.25	..	of Santiago, guide of Mr. Casanova. slopes of banks crumbled. «Camp, 22nd Novr.»
	..	..	..	..	..	..	0.01	..	0.8	high bluffs, 9 to 10 ms. over level of water, the red <i>tosca</i> is rather hard and resistant to pressure, but very soluble in water, which gives its red colour to the river. This <i>tosca</i> forms projections and irregularities on the river shore, which become visible at low water.
	751.3	..	..	20	60	..	..	1.0 ± 1.75	..	
21	752.5	..	..	10—30	60	..	..	0.40 ± 2.25	..	a series of rapids caused by considerable declivity (more than 1 metre) in the stratum of <i>tosca</i> , which shows itself as a shoal full of inequalities and deep holes, at a depth of about 40 centimetres, cut into by a channel with varying depths up to 2.35 ms. In the upper part of the rapid there was 1 metre of water and higher up a shoal with only 25 centimetres.
	754.5	..	..	..	150	..	..	0.25	..	river spreads out very much.
	756.6	..	..	60	80 ± 100	..	..	0.75 ± 3.0	..	from the NW a dry water course with its bed at half the height of the bluff of the main river.
	759.8	16.1	10	25	60	..	..	0.75 ± 0.30	..	bluffs 10 ms. high. «Camp, 23rd Novr.»
	..	..	..	..	..	..	( )	..	0.75	
	760.2	..	..	..	100	..	..	1.5	..	river spread out, full of shoals.
	762.7	..	..	15	55—90	..	..	0.7 ± 1.5	..	old channel without change, a gorge with 15 ms. across surface of water.
	768.0	..	10	30	50—60	..	..	1.0 ± 2.5	..	in salient curves banks fallen down from the top. Height of bluffs 10 ms. Another gorge.
	768.8	..	..	25	50	..	..	1.4	..	<i>tosca</i> hard, bed narrow.
	769.8	..	..	..	..	..	..	..	..	gorge between bluffs of <i>tosca</i> .
25	770.4	..	..	..	..	..	..	..	..	waterfall at low water.
	772.2	..	..	..	60 ± 100	..	..	0.75 ± 1.25	..	<i>tosca</i> hard and unequal in the bottom. Big old algarobas on the shores.
	776.5	..	10.5	20—40	70—80	..	..	0.75 ± 1.3	..	<i>tosca</i> reef, rapid in time of drought.
	781.2	21.4	..	..	60—70	..	..	0.75 ± 1.0	..	the forest above shores sparser. There are more <i>alisos</i> . «Camp, 24th Novr.»
	..	..	..	..	..	..	+0.02	..	0.60	
	782.0	..	..	..	70	..	..	1.25	..	<i>tosca</i> reef, rapid at low water. the water a little less turbid.
	786.0	..	..	..	60—80	..	..	0.75 ± 1.5	..	ledges in <i>tosca</i> in the bottom.
	787.4	..	..	..	55	..	..	..	..	river narrower.
	791.6	..	..	..	65	..	..	0.5 ± 2.0	..	river 2 ms. deep. Big Indian fishing weir.
	

(1) Over level of water.
(2) During preceding night.

DATE	Distance by river		Width		Rise or fall of river (2)	Soundings	Velocity in metres per second	OBSERVATIONS		
	accumulated from the mouth	daily run	Height of the banks (1)						of the stream	of the channel
	kms.	kms.	m.	m.	m.	m.				
November 26	801.2	20	10	35-40	65-70	..	0.6 À 1.0	..	in several parts <i>losca</i> reef across bed, causing rapids and waterfalls at low water. <i>Tolderia</i> of Ironquitos Indians. «Camp. 25th Nov.»	
	802.9	..	12	..	..	-0.02	0.8	0.23	high bluffs, extensive shoals.
	805.6	..	..	15-20	70	..	..	..	strong rapid, <i>losca</i> reef, declivity 0.50 m. Indian fishing weir in middle of rapid.
	806.4	..	12	14	..	..	0.75	..	the high bluffs (12 to 14 ms.) are withdrawn from the present river channel which remains bordered by lower banks of 5 to 6 ms. high; river then becomes very dirty, with trunks of trees, <i>raigones</i> , shoals, spreads, with a narrow (8 to 10 ms.) and tortuous channel, rather deep. There are many Indian fishing weirs.
	807.0	..	5-6	..	..	..	..	..	at km. 810.7 a promontory 11 ms. above river, remains of an old bluff cut through.
	810.7	..	5-11	..	..	..	0.6 À 0.75	..	the channel of the river begins again to be better defined with high bluffs on both sides and regular bed. At intervals small cultivated patches of the Indians on the ridge. Camp. 26th November.
	814.5	13.3	10	..	65	..	0.5 À 1.0	..	bed of river better defined, less spread out; everywhere hard red <i>losca</i> . Generally greater depth in the bends than in the straight reaches, the river charging more strongly on one side.	
	815.0	..	..	..	65	..	1.5	2	rapid, hard <i>losca</i> .
	818.0	..	..	..	..	..	1.0	..	extreme width of the channel very variable, in many parts the bluffs retire forming corners liable to be flooded.
	820.1	..	..	..	60-70	..	..	..	river very tortuous with curves that nearly complete a full turn, leaving 100 to 200 ms. distance between the banks of two turns. High forest far off towards the north.
27	824.3	..	11	50	100 À 120	..	0.75 À 1.60	..	the river full of <i>raigones</i> and branches.	
	825.3	..	..	..	..	..	0.6 À 0.75	..	great shoal in middle of river, greatly spread out. Camp. 27th November.
	827.6	14.1	..	50	150	..	0.7 À 2.0	..	the last freshet reached 2 ms. over height observed. Bluffs not so high; begin to see much red <i>quebracho</i> .	
	831.1	..	5	..	..	..	..	0.7	river very tortuous and spread out, due to the absence of the harder red earth; the upper strata are sandy and loose.
	834.5	..	..	..	100	..	1.2	..	
	835.9	..	4.5	60	100	..	1.5 À 2.0	..		

(1) Over level of water.
(2) During preceding night.

DATE	Distance by river		Height of the banks (1)	Width		Rise or fall of river (2)	Soundings	Velocity in metres per second	OBSERVATIONS
	accumulated from the mouth	daily run		of the stream	of the channel				
	kms.	kms.	m.	m.	m.	m.	m.		
November 29	843.2	15.6	4	50	100 à 150		1-1.5	..	the bluffs show openings cut by and representing the channel of the river in past times. «Camp, 28th Novr.»
	..	..	..	..	..	+0.23	..	1.4	
	843.9	..	3	70	80	..	..	2.5	bluffs of hard soil overhanging the river.
	845.8	..	3-5	30	80	..	..	..	narrow.
	846.5	..	..	..	60	..	..	1.75	to the eastward a big <i>tolderia</i>
	848.0	..	..	..	100	..	..	2.0	we continue to find vestiges of old channels in a direction across the present one. To the eastward well defined bluff and high land, to the westward low land with broad shore.
	851.7	..	3-5	..	..	..	..	1.75 à 3	earth looser, without the promontories of red <i>tosca</i> . «Camp, 29th Novr.»
» 30	857.8	14.6	..	50-70	100 à 120	..	0.5 à 2.0	..	river wide with flat shores on the side towards which it flows, *in the bed.
	..	..	..	..	..	-0.10	..	1.3*	Again hard red earth, bluffs more solid.
	860.5	..	3	60	100	..	..	2.0-3	indications on the bluffs of two recent freshets, of 1.25 and 2.5 ms. respectively above our observation.
	861.0	..	..	..	..	..	..	..	*in a bend.
	863.0	..	..	..	..	..	..	..	bluffs higher. «Camp, 30th Novr.»
	866.8	..	3-5	80	100	..	0.8 à 2.5*	..	
	871.7	13.9	4	50-80	100	..	1.1 à 1.75	..	
December 1	..	..	..	..	..	-0.02	..	1.1 à 2.5	river wide, flat shores, <i>raïgonas</i> . On the shore trunks of palms. Then came a great bend and shore spread out towards SE, loose sandy soil without <i>tosca</i> .
	876.8	..	1.5 à 3.0	70	100	..	..	1.25 à 2.5	«Paso del Tigre», depth observed 1.25 ms.
	879.4	..	3 1.25	80 à 100	100 à 130	..	..	1.0	flat shore with hard bottom, on eastern shore yellow sharp fine sand.
	881.1	..	2-3	..	..	..	..	0.5 à 1.25	again red earth. «Camp, 1st December».
	886.1	14.4	2-3	60	100	..	..	1.2 à 1.3	harder strata begin to appear in the bluffs, <i>tosca</i> or chalk somewhat blackish. River valley or channel a little narrower and better defined.
	887.6	..	..	..	..	..	..	1.3	bluffs and shoal banks in bed of river more sandy. Between kms. 893 and 894 dunes of wind driven red, sharp sand, rather fine, can be used for mortar with lime. «House of the colonist Antonio»
	891.6	..	..	..	75	..	..	1-2	river very wide and shallow, red <i>tosca</i> reappears.
» 2	893.2	..	4-5	30	100	1.25	again are noticeable reefs of hard <i>tosca</i> which cross bed of river, causing rapids at low water. «House of the colonist Echave».
	894.7	..	5	..	85	

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(2) During preceding night.

DATE	Distance by river		(1)		Width		Rise or fall of river (2)	Soundings	Velocity in metres per second	OBSERVATIONS
	accumulated from the mouth	daily run	Height of the banks	of the stream	of the channel					
						kms.				
	898.8	12.8	4-5	..	100 á 130	..	..	0.5 á 1.2	..	hard bottom, banks with terraces, little depth of water shore flat and extended. «Camp, 2nd Dec. - Buena Ventura, House of Domingo As-trada.
December 9	900.5	1.7	..	..	..	..	-0.02	1.5	..	many shoals in river, soil sandy, do not notice <i>fosca</i> below: height of the bluffs close to the river very variable, reduced in places by old channels in all directions. Width of the river bed also variable. «Camp.
10	902.2	..	..	..	..	..	-0.02	1.5 á 1.2	..	9th December .
	903.7	..	..	..	..	..	..	0.1 á 0.8	..	shallows, <i>raigones</i> , sandy soil. Total area dominated by the river between high land is several kilometres wide with a tangle of old water courses and channels.
	904.4	..	..	60 á 150	..	..	..	0.5	..	greatly spread out with shallows.
	908.0	..	..	..	..	..	..	0.75	..	«La Horqueta». From here old channel as far as «Tolderia Tronquitos», km. 80. In several parts dunes of sharp fine sand.
	910.2	..	..	..	..	..	..	2.0	..	river narrower with bluffs close to shore.
	910.8	..	..	25 70	..	..	..	0.8 á 1.5	..	narrows.
	913.6	13.1	4	25-40	80	..	..	1.5 á 3.5	..	soil firmer, river bed and channel more defined, hard <i>fosca</i> reef in some parts. «Camp, 10th Dec. House of Bañagasta.
11	..	..	..	..	..	..	-0.13	..	..	Rosario».
	914.4	..	3-4	..	75	..	..	2.5 á 0.75	..	river normal, water reaches exactly to the line of non-aquatic vegetation.
	915.5	..	..	50 70	..	..	..	2.0	..	hard red <i>fosca</i> .
	917.6	..	..	..	..	..	..	2.5	..	shoals, narrow channel. «Station Abeltana».
	919.9	..	..	..	75 á 100	..	..	1.25 á 0.6	..	house of «Prudencio el Coya».
	920.9	..	5-6	..	..	..	..	0.75	..	in the curves there are depths of 3 ms., soil soft, flat shores, narrows and rapids. House of «Antonio Anaqui», country more open, with clumps of useful woods.
	921.5	..	..	15	..	..	..	1.30	..	bluffs higher.
	922.5	..	..	..	..	..	..	..	..	narrows.
	924.5	..	7-9	60	100	..	..	1.25 á 1.5	..	in some parts nitrates noticeable.
	925.9	..	..	..	..	..	..	1.8	..	bluffs solid.
	926.8	..	8-10	..	..	..	..	2.0	..	river bed irregular, shoals, <i>raigones</i>
	928.7	15.1	..	..	..	..	..	..	..	dunes of sharp sand.
12	930.5	..	3.5	20-80	100	..	-0.05	1.5	0.85	«Choroti Tolderia», irregular bluffs, vestiges of old river channels. «Camp, 11th Dec.»
	939.1	..	4-5	60 á 100	100 á 150	..	..	0.5 á 1.25	..	
										hard <i>fosca</i> , narrows
										river spread out, irregular channel, <i>raigones</i> of algaroba, willows and <i>alises</i> , dunes of

- (1) Over level of water.
(2) During preceding night.

DATE	Distance by river		Height of the banks (1)		Width		Rise or fall of river (2)	Soundings	Velocity in metres per second	OBSERVATIONS
	accumulated from the mouth	daily run	m.	m.	of the stream	of the channel				
	kms.	kms.								
										fine sharp sand, shoals, islets.
	942.3	..	4	100	150	á 200	..	0.7-2	..	the river has cut through a sand hill leaving the banks 4 ms. high.
	943.9	15.2	..	..	..	..	..	1.1	..	dunes of fine sand frequent
December 13	..	..	..	..	..	..	+0.36	..	0.80	*Camp, 12th December.
	945.9	..	5-4	60-80	120	á 150	..	1.1	..	river spread out, shoals, very tortuous.
	948.9	..	3.5	..	..	..	..	1.75	..	extensive dunes of fine sand, bluffs irregular, many dried up <i>algaroba</i> and <i>quebracho</i> trees, channel tortuous.
	950.1	..	..	..	..	..	..	á 2.5	..	station *Trifon Viejo.
	952.5	..	4	..	100	..	..	0.75	..	narrows.
	954.2	10.3	..	..	150	..	..	1.7	..	ford and station Santa María.
	..	..	..	..	..	..	..	á 1.5	..	bluffs sandy. Dunes. *Camp, 13th December.
14	..	..	..	..	..	..	+0.05	..	..
	954.9	..	..	70	120	..	..	1.25	..	river spread out, shoals with little water.
	956.7	..	4.5	100	150	..	..	1.5	..	
	958.2	..	..	..	..	..	..	á 1.75	..	
	960.6	6.4	..	100	120	..	..	1.3	..	Bolivian fort Guachalla.
	..	..	..	..	..	..	..	..	..	from the fort up river there are paths on both banks, more or less following the sinuousities of these. *Camp, 14th December.
15	..	..	..	..	..	..	-0.06	..	..
	966.0	..	5	80	150	..	..	1-1.5	..	river spread out, soil more chalky.
	968.2	..	3	..	100	..	..	..	..	bluffs rather lower.
	970.9	..	5	60	200	..	..	1.5	..	motley aspect of bluffs, showing black clayey strata alternating with layers of sand, thus indicating different origin.
	973.8	13.2	4.5	..	150	..	..	1.5	..	channel, shores and bluffs very irregular. *Camp, 15th Decr.
16	..	..	..	..	..	..	..	á 1.75	..	
	975.0	..	4-5	100	150	..	..	2.25	1.0	river more regular in channel and bluffs, islets, shoals.
	982.2	..	3.5	100	130	..	..	1.25	..	*in the curves.
	..	..	..	..	..	..	..	á 3*	..	Little forest, on the low lands <i>alisos</i> and <i>bobadal</i> .
	..	..	..	..	..	..	..	..	..	Many trunks of <i>algaroba</i> trees embedded by old freshets and laid bare by the present stream. The Argentine shore well populated, many fenced in stock farms reaching down to the river. Long broad reaches. The station *La Paz* of Electo Sarabia.
	987.0	14.1	5	40	100	á 200	..	1-2	1.5-2	abundant <i>bobadal</i> , river spread out, greater current. *Camp, 16th December.
17	991.0	..	4.5	..	100	á 150	0.08	..	1.75	station *La Esperanza.
	996.5	8.6	4.5	40	60-80-90	..	..	1.5	..	river in parts narrower with upright bluffs on both sides; on the ridge <i>alisos</i> willows and <i>Caña de Castilla</i> , hard wood forest far from the river

1) Over level of water.

(2) During preceding night.

DATE	Distance by river		Width			Rise or fall of river (2)	Soundings	Velocity in metres per second	OBSERVATIONS
	accumulated from the mouth	daily run	Height of the banks (1)		of the stream of the channel				
	kms.	kms.	m.	m.	m.	m.	m.		
December 18	..	..	..	..	..	-0.07	..	1.5	«Nuevo Torvenir». «Camp, 7th December». river irregular, in parts spread out, in parts closed in between abrupt bluffs. On the ridge scarcely anything but <i>alisos</i> . Less current, many trunks embedded in the bluffs La Valle.
	1003.6	..	4-5	100	150	..	0.5-2	..	
» 19	1009.1	12.6	1.5	6	70-80	150	..	0.9	at intervals on both sides small cultivated patches, plenty castor oil plant. «Camp, 18th December».
	..	..	..	..	..	-0.07	..	..	reaches longer.
	1014.5	..	5-6	40-60	80	..	0.8	..	great mud shoals, river as a rule narrower. Open country without woods. Station «Costa Rica».
	1018.7	..	..	..	..	..	..	..	great spreads of the river, a very big bend to the northward.
	1020.2	..	5	6	60	130	..	1.0	bluffs irregular. Estate «Costa Rica».
» 20	1025.0	15.9	5	60	130	..	1.0	..	the earth of the bluffs rather impermeable, the water deposited by the freshets remaining for a long time. «Camp, 19th December».
	..	..	..	..	..	-0.01	..	1.2	Station «San Luis». Channel and shore better defined. soil less sandy, firmer.
	1026.8	..	5	80	130	..	1.25	..	
	1028.9	..	6-7	50-80	90	..	0.75	..	the section of the river more regular, bottom firm without shoals or little channels. «Camp, 20th Dec.»
	1034.5	..	7	30-50	35-80	..	0.8	..	
» 21	1039.8	..	9	50-70	..	80-70	1.0	..	high abrupt bluffs partly rising directly out of the water.
	1041.8	16.8	4.5	..	100	..	0.75	..	again some algaroba noticeable on the banks. «Camp, 20th December».
	..	..	..	..	..	+0.01	..	..	extensive shoals at the foot of the upright bluffs, many embedded trunks of trees.
	1043.1	..	5	70	150	..	..	..
	1045.4	..	5	..	80	..	0.85	..	river spread out, bluffs irregular and interrupted.
» 22	1051.9	..	6	..	200	..	0.75	..	river narrower with compact bluffs.
	1055.3	..	1.5-7	80	100	..	1.2	..	long straight reach with relatively low bluffs, covered with tall <i>alisos</i> . Towards the north may be seen the high bluffs of a big old channel.
	..	..	..	..	120	200	1-1.1	..	river very much spread out. «Camp, 21st Dec.»
	1056.6	14.8	5	..	250	..	..	..
	1060.1	..	..	..	150	+0.27	..	..	river broad, like a lake, flat shores, difficult to find channel among the extensive shoals covered by the turbid waters of the last freshet; the bluffs frequently present ter-

- (1) Over level of water.
(2) During preceding night.

DATE	Distance by river		Height of the banks (1)	Width		Rise or fall of river (2)	Soundings	Velocity in metres per second	OBSERVATIONS
	accumulated from the mouth	daily run		of the stream	of the channel				
	kms.	kms.	m.	m.	m.	m.	m.		
December 23	1062.0	..	..	..	300 à 500	..	3	..	rices. Towards the south there is a great cove near which is situate the property «Monte Cristo» of Francisco Valderama. The river must work much here to judge by the width of the bed. Far off to northward we noticed extensive palm forests.
	1063.6	..	..	..	..	..	..	..
	1069.4	12.8	5-6	100 à 300	300 à 500	..	1.5-3	..	station «Ovejería».
	..	..	..	..	..	-0.03	..	..	«Campo Alegre».
	1070.2	..	2-3	..	..	..	..	..	river spread out. «Camp, 22nd December».
	1072.1	..	3	70	200	..	2.70*	..	low swampy banks continue, interrupted by not very long high bluffs.
	..	..	..	..	..	..	..	..	* in the narrow parts. More algaroba noticeable on the argentine side. «Puesto del Medio». Remains of old bluffs in all directions.
	1075.5	..	6	150	..	..	..	..	rapid at low water.
	1082.7	13.3	1.5-6	..	..	..	0.9	..	river greatly spread out. Soil sandy, shoals of fine sharp sand. «Camp, 23rd Dec.»
	..	..	..	..	..	-0.05	..	..
24	1088.7	..	..	..	..	..	0.6 à 1.5	..	river continues broad without banks, with irregular bluffs, nothing constant. The total width of the area dominated by the variable course of the river reaches 2 kms. The descent to the river at the station «El Hito».
	1090.4	7.7	..	..	..	..	..	..	The intersection of parallel 22° S and the river Pilcomayo. Boundary mark N° 1, is situated 1050 metres from the shore of the river and has inscribed on it the geographical latitude: 62° 52' 8" West of Greenwich 4° 29' 53 " " " Bs. Aires

- (1) Over level of water.
(2) During preceding night.

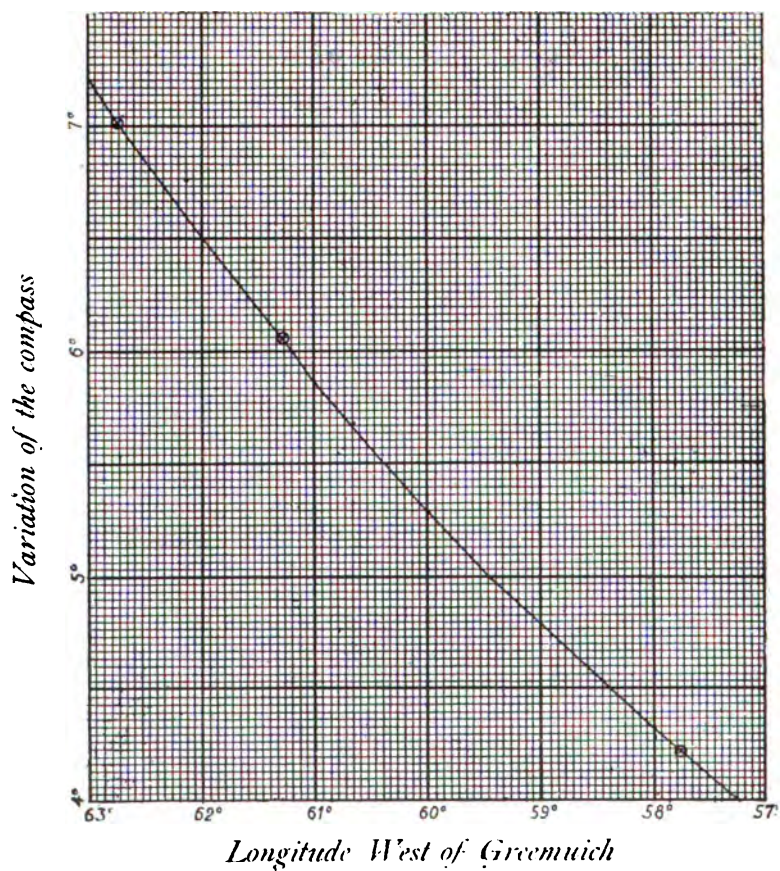
T A B L E S
OF
Observations of latitude, variations of the compass, levellings,
determinations of volume of water

LIST OF OBSERVATIONS OF GEOGRAPHICAL LATITUDE.

N.º	LOCALITY	Kms.	Latitude S	OBSERVATIONS
1	Clorinda.....	23.5	25° 16' 56"	
2	Junta Fontana	196.0	24° 56' 14"	
3	End of Mapa Sol....	297.9	24° 46' 20"	Observation taken in Arroyo Podrido.
4	Baradero	336.7	24° 38' 46"	
5	Narrows	352.9	24° 35' 31"	
6	Junta Dorado.....	381.7	24° 27' 57"	
7	Tapera Bailón.....	416.6	24° 24' 8"	
8	Junta Soret Satandi..	527.2	24° 8' 40"	Observation taken in zanjón Soret Satandi.
9	Upper Pilcomayo...	598.7	23° 58' 12"	
10	"	708.0	23° 28' 49"	
11	"	801.2	23° 5' 53"	
12	Buena Ventura.....	898.8	22° 42' 4"	Town projected.
13	Upper Pilcomayo...	960.6	22° 27' 22"	
14	"	1041.8	22° 12' 22"	
15	Station El Hito.....	—	22° 1' 24"	

DETERMINATION OF THE VARIATION OF THE COMPASS

LOCALITY	Date	Latitude S	Longitude West of Greenwich	Variation of the compass
	1905			
Clorinda.	August 18	25° 16' 56"	57° 46'	4° 13' East
Kms. 708.	November 20	23° 28' 49"	61 20'	6° 5' »
Kms. 1042.	December 20	22° 12' 22"	62° 44'	7° 1' »



PARTIAL LEVELLINGS GRAPHICALLY REPRESENTED
ON THE ANNEXED MAP.

	Sheet
1 Longitudinal section of the Arroyo Dorado from the Ojos de Agua to the junction with the river Pilcomayo..	V
2 Tapera Bailón to zanjón Bailón	»
3 Section of the Arroyo Dorado, Nizarat Km. 459.....	»
4 Section of the Arroyo Dorado, Km. 522.4.....	IV
5 Section Arroyo Dorado, zanjón Soret Satandi, river Pilcomayo	»
6 Section of the zanjón Soret Satandi	»
7 Section of the river Pilcomayo, Km. 527.4	»
8 Section from the Lagoon Grande Final to the river Pilcomayo, Km. 633.....	»
9 Section of the river Pilcomayo at Buena Ventura.....	II

DETERMINATIONS OF DISCHARGE OF WATER

N.º	LOCALITY	Date of observation	Maximum depth of the wet section	Area of the wet section in square metres	Mean velocity metres per second	Discharge of water, cubic ms. per second	Observations
		1905	metres				
	<i>Junta Fontana:</i>						
1	River Pilcomayo south branch..	Agt. 25	3.00	36.75	0.49	17.92	State of the river rather swollen.
2	Id. north branch	"	2.70	36.37	0.20	12.56	
	<i>Junta Dorado:</i>						
3	River Pilcomayo above the junction	Sept. 30	0.31	1.366	0.42	0.576	Water extremely low, drought.
4	Arroyo Dorado above the junction	"	0.12	0.345	0.40	0.138	
5	River Pilcomayo at Salto Palmares	" 29				0.200	Very pronounced drought.
6	Rivulet above the Salto Palmares	"				0.150	
7	Arroyo Dorado near Nirazat, kms. 459	Oct. 19	0.21	1.012	0.27	0.173	
8	Arroyo Dorado at Nalaik kilometres 522.4	Nov. 2	0.34	1.290	0.17	0.230	
9	Upper Pilcomayo, kilometres 527.4	" 3	3.50	36.28	1.10	40.00	Somewhat swollen.
10	Upper Pilcomayo, at Buena Ventura, kilometre 898.8	Dic. 4	0.71	49.75	0.84	42.00	Low water.
11	Idem		4.20	607.21	3.57	2170	Highest freshet; approximate calculation.

KINDS OF TREES

IN THE VICINITY OF THE RIVER, WITH REFERENCES TO KILOMETRIC DISTANCES FROM THE MOUTH.

Kms. 0 to	130	Dense forest of soft wood trees and palms.
"	130	Laurel, timbó.
"	138	Red quebracho begins.
"	150	Red palms.
"	191	Palm forests.
"	225	Palms and quebracho, not very abundant.
"	238	Palm forests.
"	250	Great marshes with «tatora» on both sides.
"	265	Forests lower, few palms.
"	273	Timbó, aliso, lecherón.
"	307	Franciscan property old mission, much red quebracho to the south.
"	320	Quebracho, jacarandá and guayacán.
"	340	Red quebracho, jacarandá, especially on the Parayan side.
"	355	Much quebracho.
"	370	Alisos. (Kms. 381,7 Junta Dorado).
"	385	Palm groves.
"	390	White quebracho and algaroba.
"	400	Algaroba and palms.
"	405	More algaroba.
"	410	Lagoon and Salina Parali, on the shores palms and algaroba.
"	415	Many palms.
"	417	Palm groves, algaroba (Tapera Bailón).
"	420	Algaroba.
"	425	Palms.
"	430	Scattered palms.
"	435	Palms and algaroba.
"	450	No forest trees, only chilca on the shore.
"	455	Palm groves towards the south.

Kms.	468	Palm groves towards the south on the shore, alisos and chilca.
"	471	Willows and a few palms.
"	473	Willows, aliso, chilca.
"	484	Algaroba, timbó, tatané, aliso, willow.
"	497	Algaroba woods.
"	500	Ceibo and algaroba.
"	503	There is no quebracho, only algaroba and some tatané, lecherón.
"	503-513	Willow, aliso, algaroba.
"	514	Country more open with groups of trees.
"	515	Timbó, palo borracho, a few palo santo, great va- riety of trees, chañares.
"	517	Extensive chañares.
"	518	On the ridge great variety of trees: timbo, palo borracho, palo santo, chañar, algaroba, on the N. E. open country.
"	528	Low woods without trees of value.
"	535	Dense forest on the ridge, a good deal of red que- bracho.
"	537	Open country, groups of trees.
"	538	Dense forest on both sides, much quebracho; palo santo, jacarandá.
"	544	Much chañar (in fruit), more forest on northern side.
"	545	Much chañar on the shore.
"	561	Forest denser, palo santo, jacarandá, much red quebracho.
"	572	A few palo borracho on the shore.
"	574	Lecherón very common.
"	575	Much red quebracho.
"	578	End of forests of hard wood, willows and alisos follow.
"	584	Dense aliso woods.
"	590 to 600	Open country on both sides as far as Lagoon «Grande Final»; willows, aliso, caña castilla, cola caballo, on the shore.
"	597	A league to the north can be seen a line of high forest.
"	600	A few timbó.
"	605	Much chañar.
"	608	A 1.5 kms. to the south aliso woods of Nogot Picoibi.
"	610	Much Castor oil plant.
"	612	Algaroba and quebracho.
"	620	Much chañar and timbó.

Kms.	624	Open country with groups of trees of little value.
»	630	Chañar.
»	640	Near by: willows, aliso, chañar, algaroba; further off quebracho woods.
»	648	Much caña castilla.
»	655	Low forest with pastured glades.
»	662	Open country.
»	673	Caña castilla, chañar, willow, aliso, algaroba continue.
»	680	Much caña castilla, some low palms on the shore, high forest 1.5 leagues from the river.
»	688	Big alisos and timbó.
»	715	Much big algaroba.
»	720	Algaroba.
»	730	Dense forest, willows, aliso, chañar, timbó, algaroba.
»	762	Algaroba, willows, aliso, caña castilla, timbó.
»	764	Very big algarobas.
»	775	Forest less dense, foliage less thick, fewer creepers; mistol and big algaroba.
»	776	Woods on the ridge sparse, more aliso.
»	804	Algaroba abundant, some mistol and white quebracho.
»	824	High forest far off towards north.
»	826	White quebracho.
»	834	Begin to see much red quebracho.
»	840	Much aliso on the shore.
»	863	Aliso, willow; hard wood forest withdrawn from river.
»	866	A few palo santo trees.
»	881	Trunks of palms.
»	894	Forest of hard wood trees, palo santo, guayacán, quebracho, red and white, algaroba.
»	913	Algaroba, timbó, tuca or aroma, aliso. To the S.W. far from the river: palo santo and red quebracho.
»	914	Willows, timbó, aliso, castor oil plant, algaroba, caña castilla; all rather stunted.
»	920	Country more open, with patches of useful woods.
»	925	Forest sparse and low, alisos, willows.
»	950	Pastured country with a little algaroba; further away no woods and far to the south palms.
»	982	Little forest; on the low lands: aliso and bobadal.
»	987	Much bobadal.
»	989	Less forest on the shores; here consequently tow

- ropes can be used, for long distances, from the crest of the bluffs; bobadal and tall willows.
- Kms. 995 On the ridge scarcely anything but alisos, far to the south lecherón.
- » 996 Alisos, willow, caña castilla; forest of hard woods distant from the river.
- » 1003 On the ridge scarcely anything but alisos.
- » 1009 Much castor oil plant.
- » 1014 Open country without woods.
- » 1040 Some algaroba on the shore.
- » 1055 Tall alisos.
- » 1060 Far off towards north extensive palm forests.
- » 1070 Algaroba on the Argentine shore.
- » 1072 More algaroba on the Argentine side.
-

CHAPTER III

SHORT SUMMARY OF THE MOST CHARACTERISTIC DATA RESPECTING THE CHANNEL OF THE RIVER PILCOMAYO

Synoptic table of altitudes, distances and declivity.

LOCALITY	Altitude over the zero of the Riachuelo Bs. As.	Distance from the mouth of the Pilcomayo		General declivity	
		Overland (*)	Along hy- draulic axis of river	Overland (*)	Along hydraulic axis of river
	metres	kilometres	kilometres		
Mouth of the Pilcomayo	75				
Baradero	94 **	160.4	336.7	0.0001	0.00006
Junta Dorado	131	196.2	381.7	0.001	0.0008
Ojo de Agua (bottom).	137	200.6	387.0	0.0014	0.0010
Estero Patiño	140	"	"	vertical	vertical
Caldá	"	239.8	438.2	horizontal	horizontal
Junta Pilcomayo, Soret				0.0001	0.00006
Satandi	145	289.8	527.2		
Buena Ventura	215	534.2	898.8	0.0003	0.00017
Parallel 22° S	285	637.0	1090.4	0.0007	0.0004

(*) Following the direction of the general course of the river.

(**) Over the determination of the altitude of Baradero, see page 14.

The calculation of the mean altitude of the Estero Patiño, or say the region from the Ojos de Agua of the Arroyo Dorado to Caldá, is based on barometric observations computed independently with points of reference in the sugar estate La Esperanza, near Ledesma and in the Franciscan Mission Laishi, on the banks of the Río Salado to the north of Formosa, with the following result:

135 observations referred to La Esperanza, altitude...	131
» » » the Franciscan Mission ..	137

adopting in round numbers 40 metres for the altitude of the essentially horizontal zone occupied by the marsh.

The altitude of the point of intersection of parallel 22° and the river Pilcomayo, is the result of the data supplied by the Boundary Commission with Bolivia, combined with our observations. Of course these altitudes must be taken as approximate; but nevertheless they may be considered as sufficiently exact for our preliminary estimates.

About 20 kilometres in a direct line from the discharge of the Pilcomayo into the river Paraguay the adjacent land begins to rise, and from there up to the Patiño marsh the river retains its high bluffs and well pronounced ridges, separating it from the lower and swampy land in the vicinity which is turned into extensive lagoons in times of freshets and which, with its short rivulets, affluents of the river, has a marked influence on the regimen of the stream.

The width of the channel varies between 90 and 30 metres, the height of the bluffs between 8 and 5 metres, and the depth of the water according to the condition of the river, from 0.50 metres at low water down stream from the Junta Fontana, to 0.30 metres and 0.20 metres in the last portion full of «raigones» near the Junta Dorado.

The volume of water in this part of the river is of course very variable. See with regard to this, the list of determinations on page 106.

Down stream from the Junta Dorado and in all the course of the lower river a gradual augmentation of volume is perceptible, this being due to springs, generally salt, in the bottom and to infiltrations from the banks.

Throughout all the distance from Junta Fontana to Junta Dorado the course of the river is obstructed by numerous «raigones» of hard wood, and especially up stream from Baradero km. 336.7 there is at times of low water a continuation of rapids caused by marked differences of level in the «tosca» which forms the bed of the river.

From the Junta Dorado the great Patiño marsh extends towards the west and north forming with its enormous «totorales», ditches and channels an interruption of the course of the river Pilcomayo of about 90 kilometres long in the general direction of the river.

The upper Pilcomayo, after joining the channel Soret Satandi, loses itself in the great lagoons Escalante, alias Colorada and Chaja with their adjacent marshes. Lower down the Arroyo Dorado, alias Tala, ends in the same manner at the point called Caldá, where begins the Estero Patiño, properly so named.

This marsh constitutes an immense horizontal plane which,

interrupted in parts by slight ridges generally denoted by the presence of palm trees, extends towards the north to distances as yet unknown.

All over this marsh wherever the stratum of soil, full of the roots of the «totorá», has been cut through by water courses, there can invariably be noted the somewhat undulating surface of a layer of impermeable hard «tosca», which probably in remote times formed the bed of a great lake of little depth which gradually was filled up by the silt brought down by the upper rivers.

The river Pilcomayo as well as the Arroyo Dorado, alias Tala, reappear in the south eastern part of this extensive marsh, presenting at the points of their reappearance a somewhat different aspect, on account of the depth of the impermeable stratum under the superficial swampy soil. The lower Pilcomayo river has its first sources or rills almost on the surface of the ground, about 7 kms. up stream from Salto Palmares. Little by little these rills unite and the channel deepens so that down stream, below the Salto Palmares, there are bluffs 4 to 5 metres high.

The water is continually excavating; here may be repeated the characteristic fact that the fall at present is situated 200 metres more to the westward than in the year 1904, when Mr. Cáceres visited it for the first time, the river having the tendency to work its way towards the northwest, deepening its channel. As already stated, a few kilometres more to the west again may be seen streams, going toward the east, having more or less a volume of flow equal to that discharged by the waterfall, and it is probable that these interrupted streams are to be found farther to the westward as far as the marshes, where the upper Pilcomayo disappears.

The Arroyo Dorado is formed by various small rivulets all of which have their source in well-eyes at the bottom of circular depressions with perpendicular walls 3 to 4 metres deep, formed in the ground which hereabout is somewhat argillaceous. In times of flood, when the marsh is covered with water, these springs form so many cascades which, owing to the erosive action of the water, work towards the west and so increase the length of the rivulets in that direction.

This action of the water itself tends little by little to dry up the marsh, an operation which will be concluded when the deepened sources of the lower Pilcomayo and of the Arroyo Dorado have been able to unite with the last channels of the upper river.

Along the southern border of the marsh can be seen the continuation, towards the west, of the Arroyo Dorado in the form of

rather deep channels fed by water that enters the marsh and by the drainage from the fields to the south.

The channel to the north of the «tapera» Ríos has a depth of 1 metre and a variable width of from 5 to 50 metres; the Bailón channel is less deep, but of greater length.

The western part of the Estero Patiño was at the time of our journey, so far dry that we could go over it on foot without difficulty in all directions.

For more details regarding the nature of the marsh and its hydrographical features see Chapter II page 16 and following.

At Caldá the Arroyo Dorado, alias Tala, again presents itself with a defined channel and higher banks, coming from the west, its water course or «thalweg», cut into the somewhat clayey soil, slowly diminishing.

Between Caldá and Lagarik there is a great spread of the river and a rapid 100 metres long, and in the extensive marshes to the north of Nirazat and Mapzat the course of the river (Arroyo Dorado) again completely ceases in years of little rain. More to the westward the height of the banks increases and in front of the channel Soret Satandi, the most advanced point of navigation in the Arroyo Dorado, the height of the banks is seen to be 4.66 metres over the level of the water with a depth of 0.34 metres, making a total depth of 5 metres for the channel.

The water course of the Arroyo Dorado extends towards west and probably drains the marshes and depressions that are independent of the water course of the Pilcomayo, from which it is separated by higher land and by another longitudinal depression, the drain course of which towards said river, forms the deep channel of Soret Satandi.

It is well to repeat here some figures taken from the sections shown on sheet IV of the annexed map.

The ridge of the Arroyo Dorado is 1.88 metres higher than the edge of the channel Soret Satandi and 0.61 metres higher than the ridge of the river Pilcomayo at the point *l*, and the bed of the Arroyo Dorado is, in the section *ef*, 0.66 metres higher than the bed of the channel Soret Satandi opposite the point *g*, and 1.71 metres higher than the bed of the river Pilcomayo in section *lm*.

Later on will be demonstrated the importance which these figures have for the problem of the connection of the upper and lower Pilcomayo.

As already mentioned in the narrative of the journey and according to the reports of the indians, there might exist a point further up, where the Arroyo Dorado has before approached the

river Pilcomayo and where in remote times the water of said river passed over to the channel of the Arroyo Dorado. The channel through which it flowed into the Arroyo Dorado, having in the course of time become obstructed, the river Pilcomayo took its present course. The cacique Kanachi, who acted as guide for the land convoy to this very important point, could not find anything of this connection and during the navigation of the upper Pilcomayo we only noticed one place where the deviation of the course of the river might have taken place—at km. 578 where there is a great spread of the river.

On reaching the upper Pilcomayo we found it somewhat swollen, the determination of the discharge on the 3rd november 1905, showing about 40 cubic metres per second; higher up, the flood was still more pronounced, having overflowed the banks and covered the ridge to a depth of 10 centimetres.

The river preserves its well defined ridge covered with hard wood forest, principally red quebracho, as far as 51 kms. from the junction Soret Satandi where there is a sudden change of level with the corresponding rapid, and a very pronounced and absolute change in the class of vegetation, to aliso, bobadal and willows.

Still the bluffs continue relatively high and the transverse sections not very variable, as far as 280 kms. from Soret Satandi, or 806 kms. from the mouth of the lower Pilcomayo. Beyond this a difference is noticeable in the consistency of the soil which becomes more sandy, and consequently the bed is less stable, giving rise to a succession of changes in the course of the river which, confined by high exterior bluffs, meanders in great bends with broad spreads of very little depth.

In this wise the river continues until beyond the boundary with Bolivia, with the exception of one or other short stretch with defined channel and high bluffs on both sides, due to some narrow zone of firmer argillaceous soil.

In some parts, the river is crossed by reefs or layers of toska a little harder than the soil in general, and at such points more sudden changes of level are caused, originating in the same manner as in the lower Pilcomayo rapids, especially at low water.

The breadth of the channel of the upper Pilcomayo varies between 30 and 35 metres in the first portion with well defined banks and from 100 to 150 metres in the regions further north where, as already stated, the lateral extension reached by the bends of the river is in some parts about 4 kilometres.

The depths of water observed in the upper river during our journey begin with 3 to 4 ms. and gradually diminish to 0.75 and

0.50 m., with one of 0.25 m. in a transverse section at km. 754 where there is a great spread of the river above a very decided rapid.

Like all rivers which rise in central mountain ranges and cross extensive plains without receiving any affluents, the river Pilcomayo loses in volume and width of channel, owing to loss of water by infiltration and evaporation.

This explains how the observation at Buena Ventura on the 4th December with the river at low water could give 42 cubic metres per second, whilst on the 4th November at km. 527.4 up stream from the junction Soret Satandi, with the river rather full, not more than 40 cubic metres per second were found.

The water in the lower Pilcomayo is relatively clear but very brackish, it being necessary in order to find potable water to look for it in the small pools on the shores of the river, or to dig wells in the sand banks. The Patiño marsh has water clearer and less brackish, and as regards the upper Pilcomayo the water is always turbid and of a reddish colour; the proportion of matter in suspension having been found by observation on the 20th Novr. to be 1.8 % of the volume and 3.2 % of the weight of water.

CHAPTER IV

NAVIGABILITY

In view of the data given above respecting minimum depths in the lower river Pilcomayo (50 centimetres below Junta Fontana and as low as 20 centimetres between Junta Fontana and Junta Dorado) it is clear that the statement made by the explorer Storm still holds good, to the effect, that the river Pilcomayo is not navigable throughout all the year and that during a great part of the year it is navegable as far as Junta Fontana for boats of not more than 1 metre draft.

As may be seen from the table in the preceding chapter, the general inclines are favourable and as far as the Junta Dorado the section of the river is very regular, although there remain as obstacles to the continues navigation, the serious want of water in times of drought and the existence of numerous «raigones» all the way from Junta Fontana up stream.

It would be easy and not very costly to clear the river of the «raigones» and as regards the want of water and consequently of depth, this could be remedied, considering the slight incline and moderate velocities of the current even in times of high flood, by the adoption of a series of locks and movable dams of relatively reduced height and of economical construction.

Although the volume of water observed at the Junta Dorado in time of drought did not reach 1 cubic metre per second, it may be considered, for reasons already given, that a short distance down stream there would be enough water for the service of the locks.

Naturally, a careful survey of the river would be necessary in order to determine the most convenient sites for the movable dams.

Another difficulty for navigation is presented by the sudden and very close turns of the river, especially in the lower portion down stream from Junta Fontana. This could be surmounted by cutting through the most pronounced turns, always bearing in mind that this would cause an increase in the incline and in the velocity of the current.

From Junta Dorado up to where the river Pilcomayo is found as it comes from Bolivia, in the region of Soret Satandi, there is no continuous navigable river, but only interrupted rivulets or brooks, which, with the exception of some short stretches, do not contain sufficient depth of water.

The Arroyo Dorado, alias Tala, presents throughout a large portion of its course, an almost ideal section for a navigable channel and the height of long stretches of its banks or ridges over the adjacent land is another factor in favour of making use, as far as possible, of this natural channel to effect the continuity between the upper and lower portions of the river Pilcomayo, interrupted by the Estero Patiño, which resolves itself into the problem of leading the waters of the upper Pilcomayo into the channel of the Dorado brook, selecting for this purpose the most advantageous points as regards distance and relative elevations which might result, after a careful study on the spot, such as naturally it was impossible to effect in the course of our rapid voyage of general exploration.

In Soret Satandi the distance in a direct line between the two water courses is 2700 metres and as stated already, the bed and ridges of the Arroyo Dorado are both higher than those respectively of the Soret Satandi and river Pilcomayo.

It is quite possible that more to the westward the two rivers come closer together and I repeat, that as points where this probably happens, may be noted the spreads of the river to the south of the rapid at kilometre 577.9 (see map sheet 4) and also the neighbourhood of the lagoon Pico Blanco alias Nogot Picoibi.

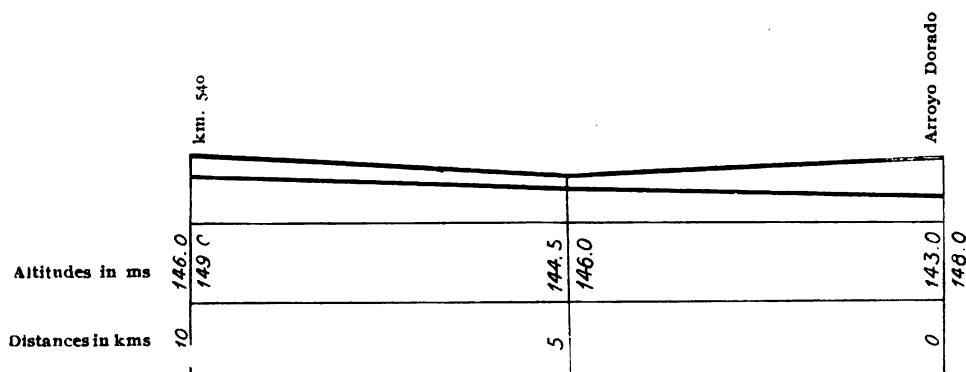
As stated above, our expedition had not time disposable to study in detail the most suitable points for uniting the upper Pilcomayo river and the Arroyo Dorado, alias Tala, and for this reason I limit myself to a consideration of the manner in which eventually the union might be effected in the region of Nalaik-Soret Satandi where we crossed with our boats, making use of the limited numerical data in my possession.

We know that the bed of the Soret Satandi and the bed of Pilcomayo are respectively 0.66 m. and 1.71 ms. lower than the bed of the Dorado at km. 522.4.

It being probable, judging from the stronger current, that the incline of the river Pilcomayo up stream from the junction with the Soret Satandi maintains itself the same as 0.00056 found in section 1 m, it would be necessary to ascend about 4 kilometres more to find the bed at the same elevation as that of the Dorado in Nalaik; and as an incline of not much less than 0.0003, would be required for a union canal, it will turn out that the point for

taking the water from the river Pilcomayo must be sought more or less at kilometre 540, shown on the map, thus giving a length of 10 kilometres to the canal which would cross the longitudinal depression extending towards the westward from the Soret Satandi channel.

The longitudinal section of this canal will be the following:



As regards the dimensions of this union canal, its section will depend on the size and draft of the boats which are to navigate it. I adopt, as a type, the tow employed in England for the transport of coal, consisting of iron boxes, 6.0 ms. long, 4.6 ms. broad, 2.3 ms. deep and 1.0 m. draft with 25 tons of cargo; six of these barges form a tow of 58 ms. long including the tug, this being more or less the length of our tow in the lower Pilcomayo, consisting of the five boats towed by the steam launch «Progreso».

For this kind of tow the following minimum section of canal is necessary.

Breadth at the bottom..... 10.00 ms.

Minimum depth 1.50 ms.

Lateral slopes 1 to 1.5 ms.

which, with an incline of 0.0003, gives a mean velocity of 0.75 m. and a volume of flow of 13.5 m³ per second.

With the longitudinal section shown above, there would be a movement of 878.969 m³ of earth, or in round numbers 900.000 m³.

It will perhaps turn out as a result of mature studies and careful surveys, as already remarked, that further up stream, points may be found for the more easy union of the two water courses, but probably the difficulty caused by the greater elevation of the bed of the Dorado compared with that of the Pilcomayo in the same geographical longitude will subsist and so render it necessary to give a considerable length to the union canal.

From Nalaik down stream the channel of the Dorado may be used as a navigable canal for about 47 kms. as far as the locality called Mapzat, km. 475, where the low and swampy land begins.

Down stream from Mapzat, as may be seen from the detailed description, the course of the Dorado crosses in parts high and hard soil where the channel is well defined with a total depth up to 3 metres, especially in the region called Lagarik, the channel in the Nirazat and Caldá regions being very superficial and passing through lagoons and marshes. At Caldá the Dorado river ceases, its waters disappearing below the floating masses of vegetation of the great marsh, to reappear in the water courses of Bailón and Ríos, to issue again in the well-eyes of said river and unite with the southern branch of the lower Pilcomayo.

It may be that studies on the spot will demonstrate the possibility of making a navigable canal in the channel of the Arroyo Dorado by regulating its bed, making use of the channels existing in the marsh and taking advantage of the relatively great difference of level between the Caldá region and the bed of the river Pilcomayo at the Dorado Junction. I consider however this alternative of very problematical advantage, as probably it would be necessary to spend large sums of money to make the canal water-tight at the upper end where it would not be cut out of the hard tosca which forms the subsoil of the marsh, and I believe it would be more practieal to abandon the region of the marsh and adopt a line for the canal through the higher land to the south of the marsh right into the channel of the Dorado, by one of the channels that constitute the natural drains of the adjoining lands, thus diminishing the movement of earth that would be necessary.

This canal would be about 70 kilometres long and if it were given the same section as the proposed union canal in the region of Soret Satandi, with an area approximately of 20 m², it would be necessary to move 1,400,000 m³. To this may be added about 600,000 m³ more, for the deepest section crossing the ridge of the Arroyo Dorado and the higher lands in the line of the canal and also as an offset to the expense of making the bottom and sides water-tight, where the canal might cross swamps and channels.

The difference of level between Mapzat and Junta Dorado must be more or less about 10 metres, with a resulting general declivity in the channel of 0.00014, which with a wet section as already stated:

Width of bed.....	10	ms.
Depth of water	1.5	"
Slope of bank	1:1.5	"

gives a mean velocity of 0.51 m. per second, requiring a volume of 9.4 cubic metres per second.

The determination of volume in the upper Pilcomayo river on the 3rd November, up stream from the junction Soret Satandi with the river rather swollen and on the 4th Dec. at Buena Ventura at ordinary low water, gave, as already stated, respectively 40 and 42 cubic metres of water per second. Although we have not yet data of observations of extreme low water in the river, I am inclined to believe from the reports I was able to gather, that the river after prolonged drought has a good deal less volume than what I have indicated above as necessary to maintain a sufficient depth of water in the canals and to secure uninterrupted navigation during all the months of the year, from the Junta Fontana to kilometre 578 in the upper Pilcomayo, where ends the zone of quebracho which follows the river. To secure sufficient water it will be necessary to provide the rivers, as well as the projected canals, with locks and corresponding movable dams, in order to raise the water to a sufficiently high level.

To limit the work to cleaning and regulating the channels so as to be able to navigate during the periods of the year when the river naturally has sufficient volume and depth, I do not consider practical, because, it being of primary importance to secure the connection between the upper and lower Pilcomayo, heavy expenses will be unavoidably necessary for the construction of the canals required to cross the region of marshes. It therefore imposes itself as the most judicious course, to execute complete canalization works and to give to this line of fluvial communication the constructions necessary to secure throughout the whole course of the year, the depth of water required for uninterrupted navigation.

Supposing that the altitude of Junta Fontana is not more than 82 metres over the Riachuelo in Buenos Aires and that of kilometre 578 being approximately 152 metres, there results a difference of 70 metres, which in times of low water must be overcome by means of locks and movable dams. Adopting 3 metres as the height of the dams and stipulating for a minimum depth of 1.5 metres, there results the necessity of constructing 47 locks for the length of river under consideration, without taking into account the very reduced depth of water running in the bed of the river in times of extreme drought, and so obtaining a maximum number of locks, which probably may be somewhat reduced when the absolute drought in the river at the different points, is known.

As the type of dam I propose the Poiré system of movable dams, which consists of wooden «needles» kept in position by movable

iron supports, so that in times of high water the needles can be taken out and stored and the supports lowered and allowed to rest on the bottom.

For the foundations and other constructive parts, the excellent wood of the region can be used, and taking into account the gentle incline and slight current even during high floods, as also the rather solid and resistant subsoil, I have calculated the cost of each, dam at \$ 32.000 currency with its corresponding lock, for a mean width of 30 metres channel.

In the lower Pilcomayo it would be necessary to effect a clearance of the numerous «raigones», especially from Baradero up stream, and to spend a relatively large amount in regulating the bed and sharpest turns of the river.

From km. 578, up stream the river Pilcomayo preserves its channel, as a rule, well defined as far as km. 806. As stated before, at km. 578 the forests of red quebracho withdraw from the river giving place to «alisos» and willows and further up, to extensive algaroba woods. The altitude of the point km. 806 over the zero of the Riachuelo, Buenos Aires, is about 190 metres.

At km. 806, as before stated, a sandy soil begins and the channel of the river in some parts dominates laterally an extension of several kilometres, caprichously changing its bends and turns and so rendering very difficult all kinds of works for regulating and canalizing it, the cost of which would be very high. The practical and rational utilization of the waters of this upper portion of the river Pilcomayo would be found in the construction of a canal for the combined purposes of navigation and irrigation, with its inlet in the Bolivian Republic at the foot of the mountains where the river flows over a firm bed worn out of consistent soil; selecting for the course of the canal the high lands with hard subsoil, to a point of reunion with the river at the above mentioned kilometre, where as I have already stated, there is a better defined channel with more stable banks.

It is proper, with a view to its canalization, to consider the river Pilcomayo from its discharge into the river Paraguay as far as km. 806, in the three following portions.

1. From the mouth up to the junction with the Arroyo Dorado.
2. From the junction with the Arroyo Dorado up to km. 578 in the Upper Pilcomayo, where the forests of hard wood cease.
3. From km. 578 to km. 806.

I present below a preliminary estimate of the canalization works and a calculation of the cost of one movable dam with lock, accompanied by an illustration showing type of same.

PRELIMINARY ESTIMATE

A. Longitudinal levelling and definitive studies	(**) \$	100.000
B. Works.		
1. Lower Pilcomayo as far as Junta Dorado. 382 kilometres.		
a) Clearance of raigones	\$	50.000
b) Regulating bed and curves	»	335.000
c) 33 locks with movable dams at \$ 32.000 each	»	1.056.000 » 1.441.000
2. From Junta Dorado to kilometre 578 in the upper Pilcomayo. 135 kilometres.		
a) Canal Junta Dorado-Mapzat. Movement of earth 2.000.000 cubic metres at \$ 0.50	»	1.000.000
b) Canal Nalaik to the Upper Pilcomayo. Movement of earth 900.000 cubic metres at 0.50 (*)	»	450.000
c) 14 locks at \$ 20.000	»	280.000
d) Clearance of raigones in Arroyo Dorado and Upper Pilcomayo	»	30.000 » 1.760.000
3. Canalization of the Upper Pilcomayo, from km. 578 to km. 806, where sandy soil begins. Total 228 kilometres.		
a) Clearance and regulation	»	100.000
b) 26 locks with movable dams at \$ 40.000	»	1.400.000 » 1.140.000
	\$	4.441.000
Expenses, general and unforeseen	»	559.000
	\$	<u>5.000.000</u>

(*) The price of 50 cents per cubic metre of earth moved, has been based on the facility for obtaining cheap labour by employing indians.

(**) Argentine currency \$ 1.00 = 21 pence Stg.

CALCULATION OF COST
OF LOCK WITH MOVABLE DAM—HEIGHT 3.30 METRES.
TOTAL LENGTH OF LOCK AND DAM 31 METRES

	Quantities	Price per unit \$	\$	\$
Definitive studies, perforations			1.000,—	
Constructions for exhausting water			2.500.—	
House, shed			1.000.—	4.500.—
Excavation, partly dry and partly in water.....m ³	1.000	1.50		1.500.—
Dam and lock:				
Piles, in place	360	15.—		5.400.—
Hard wood.....m ³	141	50.—		7.050.—
Soft wood (palo blanco) m ³	69	40.—		2.760.—
Iron for supports, including freight, .....tons	456	146.50		668.—
Galvanized bolts and nails, including freight.... kgs.	2.000	0.53		1.060.—
Wooden construction.....m ³	210	20.—		4.200.—
Blacksmith work..... kgs.	4.560	0.20		912.—
Plankpiling				1.000.—
Paint				600.—
Tools				500.—
				<u>30.150.—</u>
Unforeseen				1.850.—
				<u>32.000.—</u>
				\$.....

The result of the preliminary estimate shows, that for an outlay of 5.000.000 dollars currency, it is possible to canalize the river Pilcomayo, up to a point 500 kilometres distant in direct line from the discharge into the river Paraguay, and 60 kilometres in a direct line down stream from the important colony Buena Ventura; thus creating a means of communication by river, available at all times of the year, of economical working and conservation and of great importance for these regions, rich in woods and fertile lands.

GLOSSARY

- Aliso** (local **Boba**): *L. TESSARIA ABSINTIOIDES*.
Alisales: groves of aliso trees.
Aloja: fermented drink made from the algaroba bean.
Arroyo: brook.
Brea: *L. CÆSALPINIA PRÆCOX*. Ruiz et Pav. (Leguminosæ).
Bobadal: grove of aliso or boba trees.
Camalote: floating patches of aquatic vegetation.
Caña castilla: *L. ARUNDO DONAX*. Cane.
Carancho: *L. POLYBORUS TARO*.
Carizo: *L. PANICUM LEUCOPHÆUN*.
Caraguati: *L. BROMELIA ARGENTINA*. Baker. (Bromeliaceæ).
Ceibo: *L. ERYTHRINA CRISTA*. Galli L. (Leguminosæ).
Chacaré: Alligator.
Chaja: *L. CHAUNIA CHAVARRIA*.
Chañar: *L. GOURLIEA DECORTICANS*. Gill. (Leguminosæ).
Charata: *L. ORTALIS CANICOLLIS*. (Wagl). Wild hen.
Chilca: *L. BACCHARIS SALICIFOLIA*.
Cola de caballo: *L. EQUISETUM RAMOSSIMUM* DESF., *Á GIGANTEUM* L. (Equisetaceæ).
Cuervo: a species of black buzzard *CATHARISTES URUBU* (Vieill).
Dorado: *L. SALMINUS BREVIDENS*.
Estero: Marsh.
Guayacán: *L. CÆSALPINIA MELANOCARPA*. Griseb. (Leguminosæ).
Jacarandá: *L. JACARANDA CHELONIA*.
Lapacho: *L. TABEBUIA AVELLANEDÆ*. Lorentz. (Bignoniaceæ).
Lecheron: *L. SAPIUM AUCUPARIUM*.
Manduvina: *L. ZANTHOXYLUM* SS *RUTACEÆ*.
Mistol: *L. ZIZYPHUS MISTOL*. Griseb. (Rhamnaceæ).
Nangapiri: *L. EUGENIA GLAUCESCENS*.
Obraje: lumber establishment.
Palo boracho: *L. CHORISIA SPECIOSA*.
Palo blanco: *L. CALYCOPHYLLUM MULTIFLORUM*.
Palo santo: *BULNESIA SARMIENTI* LORENTZ (Zygophyllaceæ).

Raigones: Remains of fallen trees, embedded and submerged (snags).

Raya: a species of flounder with a strong venomous pointed tail.

Riacho: rivulet.

Sábalo: *L. PROCHYLODUS PLATENSIS*.

Surubi: *L. PLUTYSTOMA ORBIGNIANUM* VAL.

Tapero: a hut.

Tatané: *L. ENTEROLOBIUM CONTORTISILIQUUM*.

Timbó: *L. ENTEROLOBIUM TIMBOUYA*.

Tolderia: Indian village.

Torcasa: *L. COLUMBA MACULOSA* TEMM. Kind of big wild pigeon.

Tosca: calcareous concretion.

Totora: *L. TYPHA DOMINGUENSIS*. An aquatic cane.

Tuca or **Aroma**: *L. ACACIA CAVENTIA* HOOK. & ARN. (Leguminosæ).

Tusca: *L. ACACIA AROMA* GILL (Leguminosæ).

Viejita: Species *PLEOCOSTOMUS*. A thin bony fish of little value.

Zanjón: ditch or channel.

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